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THESIS

VIDEO TELECONFERENCING INTEROPERABILITY ISSUES IN THE DEPARTMENT OF DEFENSE

by

Joseph A. Couch
Jerry R. Stidham

June, 1995

Thesis Advisor: Paul H. Moose
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This thesis discusses current interoperability issues that exist with video teleconferencing systems in the Department of Defense (DoD). Recent advances in video compression and the creation of a high speed digital communications infrastructure have caused a proliferation of video teleconferencing networks and systems throughout the DoD.

The current array of video teleconferencing systems within the DoD is followed by a discussion of interoperability problems. This information medium has not fully reached its potential due in part to interoperability issues such as dissimilar compression algorithms, incompatible transmission speeds and carriers, and transmission security equipment. This is followed by a detailed analysis of standards which are currently making positive impacts these interoperability problems.

Finally, a migration strategy is recommended that is designed to overcome many of the interoperability issues presented. Additionally, transmission security and future growth issues are explored, and their applicability to video teleconferencing.

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ABSTRACT

This thesis discusses current interoperability issues that exist with video teleconferencing systems in the Department of Defense (DoD). Recent advances in video compression and the creation of a high speed digital communications infrastructure have caused a proliferation of video teleconferencing networks and systems throughout the DoD.

The current array of video teleconferencing systems within the DoD is followed by a discussion of interoperability problems. This information medium has not fully reached its potential due in part to interoperability issues such as dissimilar compression algorithms, incompatible transmission speeds and carriers, and transmission security equipment. This is followed by a detailed analysis of standards which are currently making positive impacts on these interoperability problems.

Finally, a migration strategy is recommended that is designed to overcome many of the interoperability issues presented. Additionally, transmission security, future growth issues, and their applicability to video teleconferencing are explored.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACTS	Advanced Communications Technology Satellite
AFB	Air Force Base
AFCEA	Armed Forces Communications and Electronics Association
AITS-JPO	Advanced Information Technology Services - Joint Program Office
ANSI	American National Standards Institute
AP	Application Package
AP3	Application Package 3
ARPA	Advanced Research Project Agency
AT&T	American Telephone and Telegraph
ATDNet	Advanced Technology Demonstration Network
ATM	asynchronous transfer mode
AUTOVON	Automatic Voice Network
BAS	bit-rate allocation signal
BBP	baseband processor
BCH	Bose, Chaudhuri, Hocquengham
BONDING	Bandwidth On-Demand Interoperability Group
BRI	Basic Rate Interface
C-band	4 - 8 gigahertz
C&I	control and indication
C2	command and control
C3	command, control, and communications
C4	command, control, communications, and computers
C4I	command, control, communications, computers, and intelligence
C4IFTW	C4I for the Warrior
CATV	cable television
CCEP	Commercial COMSEC Endorsement Program
CCI	controlled cryptographic item
CCITT	International Telephone and Telegraph Consultive Committee
CD-ROM	compact disk - read-only memory
CENTCOM	U.S. Central Command
CESN	CNET Electronic Schoolhouse Network
CFC	combined forces commander
CIF	common intermediate format
CINC	commander in chief
CINCLANTFLT	CINC, U.S. Atlantic Fleet
CINCPACFLT	CINC, U.S. Pacific Fleet
CINCUSNAVCENT	CINC, U.S. Navy - Central Command
CINCUSNAVEUR	CINC, U.S. Navy - European Command
CLI	Compression Labs, Incorporated
CN	communication network
CNET	Chief of Naval Education and Training
CNO	Chief of Naval Operations

CODEC	coder-decoder
COE	common operating equipment
COMSEC	communication security
CONUS	continental United States
COS	Corporation for Open Systems International
COTS	commercial off-the-shelf
CPE	customer premise equipment
CSU	channel service unit
CV	aircraft carrier designation
CVTS	Compressed Video Transmission Service
DASD	Deputy Assistant Secretary of Defense
DBOF	Defense Business Operating Fund
DCT	discrete cosine transform
DCTN	Defense Commercial Telecommunication Network
DECCO	Defense Commercial Communications Office
DES	Data Encryption System
DIA	Defense Intelligence Agency
DII	Defense Information Infrastructure
DISA	Defense Information Systems Agency
DISN	Defense Information Systems Network
DITCO	Defense Information Technology Contracting Office
DMI	Director of Military Intelligence
DMS	Defense Message System
DMSO	Defense Modeling and Simulation Office
DMUX	demultiplexer
DNCC	DCTN Network Control Center
DoD	Department of Defense
DS-1	North American pulse code modulation line rate of 1.544 Mbps
DSCS	Defense Satellite Communication System
DSI	Defense Simulation Internet
DSN	Defense Switched Network
DSNET3	Defense Information Services Network 3
DSU	data service unit
E3	end-to-end encryption
ECS	encryption control signal
EIA	Electronics Industry Association
EIG	Executive Interest Group
EPROM	erasable programmable read-only memory
FAS	frame alignment signal
FEC	forward error correction
FIPS	Federal Information Processing Standard
fps	frames per second
FT-1	fractional T-1
FTS-2000	Federal Telephone System - 2000

GCCS	Global Command and Control System
GII	Government Information Infrastructure
GSA	General Services Administration
HDTV	high-definition television
HQ	headquarters
I/O	input/output
IBM	International Business Machines
IDNX	Integrated Digital Network Multiplexer
IMUX	inverse multiplexer
INE	in-line encryptors
INMARSAT	International Maritime Satellite
INTELSAT	International Telecommunication Satellite
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISO	International Organization for Standards
ITU	International Telecommunication Union
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
JDISS	Joint Deployable Intelligence Support System
JIEO	Joint Interoperabilty Engineering Organization
JMCIS	Joint Maritime Command Information System
JPEG	Joint Photographic Expert Group
JWICS	Joint Worldwide Intelligence Communication System
JWID	Joint Warfare Interoperability Demonstration
Ka-band	26 - 40 gigahertz
kbps	kilobits per second
Ku-band	12 - 18 gigahertz
LAN	local area network
LBRV	low bit-rate video
LHD	landing helicopter deck
LOS	loss of synchronization
MBONE	Multicast Backbone
Mbps	megabits per second
MCCTA	Marine Corps Computer and Telecommunications Activity
MCTSSA	Marine Corps Tactical Software Support Activity
MCU	multipoint control unit
MCVTC	Marine Corps Video Teleconference
MIL STD	military standard
MISSI	Multilevel Information Security System Initiative
MLS	multilevel security
MMI	man-machine interface
MPEG	Motion Picture Expert Group
MUX	multiplexer
NAFNET	Numbered Air Forces Network

NASA	National Aeronautics and Space Administration
NCA	National Command Authority
NEP	Network Enhancement Program
NES	Network Encryption System
NET	Network Equipment Technologies, Incorporated
NII	National Information Infrastructure
NIST	National Institute of Standards and Technology
NITFS	National Imagery Transmission Format Standard
NIUF	North American ISDN Users Forum
NMIC	National Military Intelligence Center
NSA	National Security Agency
NSF	National Science Foundation
NTCC	Naval Telecommunication Center
NTSC	National Television System Committee
OASD	Office of the Assistant Secretary of Defense
OC-3	optical carrier 3
OCONUS	outside continental United States
OFB-64	64-bit output feedback module
ONI	Office of Naval Intelligence
OSI	Open Systems International
PACAF	U.S. Air Force - Pacific
PACE	Priority Access Control Enable
PAL	phase line alteration
PC	personal computer
PDA	personal digital assistant
pel	picture element
PEO	Program Executive Office
PICS	Profile Implementation Conformance Statements
POP	point of presence
POTS	plain old telephone service
PSN	public switched network
PSTN	public switched telephone network
QCIF	quarter common intermediate format
RBII/VP	Rembrandt II/Vision Processor
RD	receive data
RF	radio frequency
ROK	Republic of Korea
ROM	read-only memory
RT	receive timing
SAFENET	Survivable Adaptable Fiber-optic Embedded Network
SC	service channel
SCI	special compartmented information
SCVTS	Switched Compressed Video Transmission Service
SD	send data

SDNS	Secure Data Network System
SEN	Satellite Education Network
SG3	Software Generation 3
SMSK	serial minimum shift keying
SONET	synchronous optical network
SPAWAR	U.S. Navy Space Warfare Center
ST	send timing
STU-III	Secure Telephone Unit - III
TA	terminal adapter
TACCIMS	Theater Army Command and Control Information Management System
TAMC	Trippler Army Medical Center
TCCS	Theater Command and Control System
TCP	Transmission Control Protocol
TDMA	time division multiple access
TNET	Teletraining Network
TRADOC	U.S. Army Training and Doctrine Command
TRANSCOM	U.S. Transportation Command
TT	terminal timing
TVSSC	TACCIMS Video Support System Combined
TWBNet	Terrestrial Wideband Network
URL	uniform resource locator
USACOM	U.S. Atlantic Command
USARSPACE	U.S. Army Space Command
USCINCPAC	CINC, U.S. Pacific Command
USPACOM	U.S. Pacific Command
USSOCOM	U.S. Special Operations Command
VHS	Video Home System
VIXS	Video Information Exchange System
VNMC	Video Network Management Center
VSAT	very small aperture terminal
VTC	video teleconference
VTC-2	video teleconference - two point
VTC-M	video teleconference - multilocation
VTU	video teleconferencing unit
WTSC	World Telecommunication Standardization Conference
WWMCCS	Worldwide Military Command and Control System
XTP	Express Transfer Protocol

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EXECUTIVE SUMMARY

This thesis highlights the current state of video teleconferencing interoperability in the DoD and examines methods for improvement. There are at least fifteen known VTC networks within the various service components, but these networks have not fully reached their potential due to interoperability issues such as incongruous compression algorithms, dissimilar transmission speeds, a mix of public and private carriers, and incompatible communications security equipment. The principal research question is "Can VTC interoperability be achieved within DoD in a reasonable amount of time and at a reasonable cost?"

There currently is no comprehensive reference document in existence which describes the VTC assets available within the DoD and their present state of interoperability. Many stovepipe, as well as interoperable VTC networks/systems, exist throughout DoD, as do standards for their use and future procurement. This thesis also attempts to produce a consolidated document containing descriptions of DoD VTC systems, a discussion of standards for their use and procurement, a migration path for future interoperability, a discussion of transmission security, and a look at future growth issues and their effects on DoD.

Chapter II provides the reader an overview of VTC networks and systems used in DoD today. Joint systems are highlighted first, followed by Service component systems. Each system is defined within the analytical framework of system description, primary mission, network interface (data rate, compression algorithm, public or private network), and operating costs when available. Sixteen systems are discussed.

Chapter III discusses interoperability problems associated with current VTC systems. Interoperability requirements for current and future systems are provided in hopes of giving the reader an overview of shortcomings that affect VTC. Issues such as data rate compatibility, non-proprietary compression algorithms, and the choice of transmission carriers are highlighted as the key attributes of an interoperable VTC system. The topic of transmission security is briefly introduced.

Chapter IV introduces the concept of standards, identifies the important standards making bodies, and highlights the standards of these organizations which impact VTC. A chronological explanation of how the DoD arrived at its present position with regards to VTC

standards is presented. A brief look at the standards which will impact the future of VTC concludes the discussion of standards.

Chapter V outlines a migration strategy for the use, development, and acquisition of VTC systems, with global interoperability being the ultimate goal. This strategy encompasses continued progress in the development of multipoint and audiographics standards, investment in infrastructure such as adding switched digital services to the DSN, and research into leading edge technologies that show promise for integration into future VTC systems and networks.

Chapter VI continues with the topic of transmission security introduced in Chapter III. Transmission security requirements for a VTC system record the user organization's desired level of protection for its information and other system resources. Three levels of security protection for information transmitted between VTC systems are introduced. The transmission of sensitive but unclassified information using DES, and the transmission of classified information using link/bulk encryption over VTC systems are discussed. Lastly, multilevel security (MLS), the enabling technology to achieve secure information system integration is introduced.

Chapter VII offers a glimpse into what the future may hold for DoD video users. Key advances in standards, networks, CODECs, and user requirements and how they will affect the landscape of VTC are presented. These factors are combined to offer the reader a prediction of the state of VTC in the year 2010. The chapter concludes with a discussion of both industry and DoD's visions of VTC in the future. Similarities and differences between the two visions are highlighted.

The thesis concludes by determining that DoD can indeed achieve VTC interoperability within a reasonable amount of time and at a reasonable cost. The key to doing so, however, lies in development of an overall vision which encompasses open systems (standardization), commercial technologies, and acceptance of VTC as an application overlaid onto a ubiquitous, global network.

I. INTRODUCTION

The concept of teamwork in warfare is not new. In modern warfare, however, the increasing complexity of multiple force operations is new. These operations demand improved information systems, with seamless interfaces, to process, plan, order, and coordinate the maneuver of forces and weapons systems horizontally and vertically throughout the battlespace. (Sullivan, 1993)

Recent advances in video compression and the creation of a high speed digital communications infrastructure has caused a proliferation of video teleconferencing networks and systems throughout the Department of Defense (DoD). Today's joint operational environment requires that service and combatant commands (CINC) command and control systems share information quickly enabling decisions to be made rapidly and accurately. Video teleconferencing provides such a decision making capability, allowing DoD decision-makers from multiple organizations to meet face-to-face, in more than one place, at the same time, without the costs and delays of travel.

The Defense Commercial Telecommunications Network (DCTN) is the largest video teleconferencing network in use in the DoD today. DCTN connects over 140 government and defense organizations. There are at least another fifteen known networks that support video teleconferencing within the individual service components. These include the National Aeronautics and Space Administration's (NASA) Advanced Communications Technology Satellite System (ACTS), the Navy's Video Information Exchange System (VIXS), and the Air Force's Video teleconferencing Network (NAFNET).

But this information medium has not fully reached its potential due to interoperability issues such as dissimilar compression algorithms, mixed public and private networks, and

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incompatible transmission speeds and carriers. Prior to October of 1993, DoD had approached video teleconferencing as a service, not as a system, directly contributing to the interoperability problems that still exist today. To solve this problem, the Defense Information Systems Agency (DISA) was tasked and budgeted to oversee video teleconferencing within DoD (Castleman, 1993).

Progress is being made. The DoD and the Office of the Assistant Secretary of Defense for C3I (OASD(C3I)) recently formed an alliance with the Corporation for Open Systems International (COS). These groups, working together, approved a profile which outlines standards for video teleconferencing systems operating between transmission data rates of 56 and 1,920 kbps, effective October 31, 1994. This profile is based on the international standards from the International Telecommunications Union-Telecommunication Standardization Sector (ITU-T) for video teleconferencing, specifically the H.320 series of recommendations.

DISA's Joint Interoperability Engineering Organization (JIEO) division is formulating a standards architecture for the future, which will support the migration of legacy systems that were procured prior to the adoption of COS Profile standards. This architecture, once implemented seeks to achieve global video teleconferencing interoperability. This architecture is only in the development stage at this point, and is far from being realized.

A. PURPOSE OF THESIS

This thesis will examine the many VTC systems in use today by DoD, issues surrounding the interoperability of VTC systems, and standards referring to video teleconferencing. In addition, it will look at a migration path to global interoperability,

transmission security , and future growth issues in video teleconferencing. The principal research question is "Can video teleconferencing interoperability be achieved within the DoD in a reasonable amount of time and cost?"

Currently, no single reference document exists which details the state of video teleconferencing in the DoD. Many stovepipe, as well as interoperable video teleconferencing networks/systems exist throughout DoD, as do standards for their use and future procurement. The intent of this thesis is to produce a consolidated document containing descriptions of DoD video teleconferencing systems, a discussion of standards for their use and procurement, a migration path for future interoperability, a discussion of transmission security, and a look at future growth issues and their effects on DoD.

B. CHAPTER SUMMARY

Chapter II provides a detailed description of video teleconferencing networks and systems in use in DoD today. Joint systems are discussed first, followed by Service component systems. Each system is defined using the following analytical framework: system description, primary mission, network interface (data rate, compression algorithm, public or private network), and operating costs when available.

Chapter III outlines interoperability problems associated with current video teleconferencing systems. Interoperability requirements for current and future systems are discussed to give the reader an overview of shortcomings that affect video teleconferencing. Issues such as data rate compatibility, non-proprietary compression algorithms, and the choice of transmission carriers are highlighted as the main attributes of an interoperable video teleconferencing system.

Chapter IV is a detailed discussion of standards. ITU-T international standards (formerly CCITT) are highlighted as the replacement to the former Military Standards. This is followed by a discussion of the Corporation for Open Systems (COS), to give the reader a background of the significance of the government's alliance with industry to accelerate the deployment and use of standards-based networks and systems.

Chapter V outlines a migration path to incorporate legacy video teleconferencing systems into today's standards-based architecture, including how it will support future procurement. Ongoing efforts to standardize legacy systems such as the DCTN Network Enhancement Program II (NEP II) are addressed. Recent technologies such as Low Bit Rate Video (LBRV) and secure multi-point video are considered and their introduction into existing architecture is highlighted. This is followed by a look at the trade-offs required to standardize and protect investments.

Chapter VI explores transmission security. The equipment required for secure point-to-point and multi-point video teleconferencing is described. National Security Agency (NSA) standards for transmission security are highlighted. This is followed by a detailed description of cryptographic equipment connection to current systems. This chapter concludes with an examination of multi-level security and how it will influence the future of secure video teleconferencing.

Chapter VII discusses future growth in the video teleconferencing industry. A prediction of the video teleconferencing landscape in the year 2010 based on visions from DISA and industry are presented. Topics such as PC-based video, shared desktop operations, and collaborative workstations are outlined.

Finally, conclusions and recommendations will highlight what interoperability solutions will work best in support of the warfighter.

II. DISCUSSION OF SERVICE SYSTEMS

A wide range of video teleconferencing systems are currently in use throughout the DoD. These systems come in a variety of sizes depending on the users needs. The primary considerations for selecting a video teleconferencing system are the number of users, the required bandwidth (which affects quality), and the ease of use. PictureTel, Compression Labs, and VTEL Corporations are the principal U.S. manufacturers of video teleconferencing systems, and collectively supply ninety-seven percent of the market (Flanagan, 1993).

Video teleconferencing systems can be classified into three categories: small desktop systems, medium sized roll-about systems, and large room-based systems. Desktop systems are the newest technology available. These systems are comprised of a small camera which mounts on top of a computer's monitor, and a coder-decoder (CODEC). A CODEC is an electronic device that converts analog signals, typically video, voice, and/or data, into digital form and compresses them into a fraction of their original size to save frequency bandwidth on a transmission path. Desktop systems operate at data rates between 56 and 128 kbps over local area networks (LANs) or phone lines, and provide video images at 10 to 15 frames per second (fps). Costs of these systems range from 2,000 to 5,000 dollars. Medium sized roll-about systems offer a greater level of flexibility to the user by providing larger monitors, more system features and the ability to operate at greater transmission speeds. These systems can operate at data rates between 56 and 768 kbps over a variety of transmission mediums, supplying video images at 15 to 30 fps. Costs of roll-about systems range from 16,000 to 60,000 thousand dollars. Larger room-based systems are being phased out in lieu of roll-

about systems, with the exception of those being used for classroom distance learning. These systems offer less flexibility to the user, at a significantly higher cost to install and operate. Room-based systems generally operate at higher data rates between 384 kbps and 2.048 megabits per second (Mbps), supplying video images at 30 fps (television quality). Costs of these systems can range between 100,000 to 1,000,000 dollars.

The majority of the video teleconferencing systems in operation in the DoD today are room-based systems installed as part of the DCTN contract in the 1980s. However, advances in technology and decreases in price have caused a proliferation of roll-about and desktop video teleconferencing systems in the DoD over the past two years.

It is important to distinguish the difference between a video teleconferencing system and communication network. A video teleconferencing system is the peripheral equipment that supplies video images for transmission over a communications network. Both types of systems exist in DoD, and are discussed because each contributes in its own way to today's interoperability problems. The following sections provide brief descriptions of the known video teleconferencing and communication networks that are in use in DoD today. Joint systems are discussed first, followed by a description of service specific systems.

A. DEPARTMENT OF DEFENSE JOINT SYSTEMS

1. Defense Commercial Telecommunications Network (DCTN)

DCTN is a large digital integrated voice, video, and data network that AT&T is providing for the DoD on a ten year contract which expires in March 1996. The network is an all terrestrial, (with the exception of Hawaii which is connected by undersea fiber optic

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cable) closed network managed and controlled by AT&T from the DCTN Network Control Center (DNCC) in Dranesville, Virginia. DCTN is managed by the Defense Information Systems Agency (DISA) at its headquarters in Arlington, Virginia. DCTN is the designated transmission medium for all DoD video teleconferencing projects.

DCTN and DoD's automatic voice network (AUTOVON) were designated as sub-networks of the larger Defense Switched Network (DSN) in 1990. The names DCTN and AUTOVON were eliminated in 1993. Technically, DCTN no longer exits and there is only the DSN. However, since the DCTN contract does not expire until March 1996, the name is still used and is synonymous with DoD video teleconferencing.

DCTN is designed to be the primary video teleconferencing system during peacetime, periods of crisis, pre-attack, theater non-nuclear, and post attack phases of war. Key users include the National Command Authority (NCA), Commanders in Chiefs (CINCs) of the Unified and Specified Commands within the continental United States (CONUS), and strategic and tactical subordinate commanders. The DCTN family of video teleconferencing systems are room-based systems, that allow for secure and non-secure video teleconferencing applications in point-to-point, multi-point, and off-net modes of operation at DS-1 (1.544 Mbps) data rates, between designated DoD locations within CONUS, Alaska, and Hawaii. DCTN service does not extend to overseas locations such as Europe or Korea. The basic standard system configuration includes monitors, a single chip camera with pan/tilt/zoom/focus capability, radio frequency (RF) room controller with panel volume control, audio system with echo canceler, two microphones, mute and record status indicators, and a time of day clock.

DCTN systems predominantly incorporate the Compression Labs Incorporated (CLI) Rembrandt family of video teleconferencing equipment. The Rembrandt family consists of the Rembrandt, Gallery, Rembrandt II/06 and Rembrandt II/Vision Processor (RBII/VP) systems. The Rembrandt family of CODECs can use a variety of compression algorithms which include CTX or CTX Plus, that are included with the systems application package (AP). The majority of DCTN facilities have been upgraded with RBII/VP CODECs, running application package four which can supply video images at frames rates up to 30 fps. The RBII/VP is the only CLI CODEC capable of supporting the International Telecommunications Union-Telecommunications Standardization Sector (ITU-T) H.261 compression standard, and is interoperable with other standards compliant systems manufactured by other companies. Transmission security is achieved using KG-194 or KG-81 communications security (COMSEC) equipment in line with the system's CODECs. There are currently over 140 DCTN video teleconferencing facilities in use at all levels of the DoD.

Video teleconferencing is provided by AT&T at the DS-1 rate of 1.544 Mbps. This consists of (VTC-2) two point video teleconferencing and (VTC-M) multilocation video teleconferencing. VTC-M service provides interactive video and audio conference capabilities that allow the conference chair-person to direct a meeting encompassing many separate locations. In December of 1990, AT&T began providing video teleconferencing at the 384 kbps sub-rate for selected users. Usage is reservation based, and centrally managed on a first come first serve basis.

Video teleconferencing using the DCTN is expensive. Flat rate monthly charges are based on usage twenty-four hours a day, seven days a week and the bandwidth of the studio

connection. Rates vary, depending on the distance between the video teleconferencing studio location and the AT&T point of presence (POP). These charges can range from approximately $8000 per month for a 384 kbps connection to $13,000 per month of connection at the DS-1 rate. A DCTN studio can cost hundreds of thousands of dollars to build, with monthly operating costs averaging thirteen thousand dollars (AT&T, 1994).

DoD is currently in the process of designing a DCTN follow-on (post March 1996) architecture. The Defense Information Systems Network (DISN) program office has been designated by DISA to design the DCTN follow-on network. The network architecture is unclear at this time. However, it is expected that regardless of architecture details, or the proposed contractor, the follow-on network will include new technologies such as bandwidth on demand and usage sensitive billing.

2. Joint Worldwide Intelligence Communications System (JWICS)

JWICS is a Defense Intelligence Agency (DIA) initiative to address the inadequacies of current intelligence systems to support the warfighter. The intelligence communities bandwidth requirements have grown significantly with the introduction of new national level intelligence systems such as the Joint Deployable Intelligence Support System (JDISS). This combined with the current need for imagery and video, and the operational life of the current intelligence system, the Defense Information Services Network (DSNET3) nearing its end, brought about the need for JWICS.

The primary mission of JWICS is to provide data and multimedia communications services to DoD and DIA intelligence users. JWICS is currently operational at twenty locations, with switching centers on-line at the Pentagon, DIA, Transportation Command

(TRANSCOM), and United States Central Command (CENTCOM). Planned network expansions include the transition of DSNET3 public switched networks (PSNs) to JWICS at over one hundred operational locations.

JWICS predominantly uses CLI's Rembrandt family of video teleconferencing systems, purchased through an existing DCTN contract with AT&T Federal Systems. These systems utilize RBII/VP CODECs, running application package three's (AP3[1]) CTX Plus proprietary compression algorithm, which provides video images at frames rates up to 30 fps. Videoconferences can be conducted at data rates between 56 kbps and the DS-1 rate. JWICS video sites are approved by the Director of Military Intelligence (DMI), and twenty sites are currently on-line. A total of 109 video capable JWICS sites are planned.

All JWICs video sites are interconnected by commercial DS-1 circuits leased through the Defense Information Technology Contracting Office (DITCO, formerly DECCO), at Scott Air Force Base, Illinois. Voice, data, and video data are multiplexed at JWICS sites using the Network Equipment Technologies (NET) Integrated Digital Network Multiplexers (IDNX) for transmission over DS-1 circuits. Future plans include desktop VTC, multimedia messaging, and distributed multimedia database management. JWICS is capable of operating up to the TOP SECRET, Special Compartmented Information (SCI) level, using KG-81, KG-94, or KG-194 COMSEC equipment.

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[1]CLI systems come with four different application packages. AP3 can provide video at 15 fps using CTX, 10 fps using QCIF, 30 fps using CIF, and 30 fps using CTX Plus.

3. SCAMPI

SCAMPI is a telecommunications system created to allow the dissemination of command, control, communications, and intelligence (C3I) information throughout the United States Special Operations Command (USSOCOM). SCAMPI is not an acronym, it's a term identified with a communications capability. SCAMPI is a closed system of communications nodes, and is the principal C3I transmission medium for USSOCOM. The primary mission of SCAMPI is to allow C3I dissemination between USSOCOM, its components, and their major subordinate units, and selected government agencies and activities directly associated with the special operations community. The SCAMPI system currently interconnects thirty sites, each called a node, with Fort Bragg, North Carolina serving as the controlling hub providing management and control flow information throughout the system (USSOCOM, 1993).

Video teleconferencing is just one of the command and control applications that ride the SCAMPI system. USSOCOM predominately uses the PictureTel System 4000 series of video teleconferencing equipment, mostly models 400 and 800. These are medium-sized roll-about systems which are operated at data rates between 56 kbps and 768 kbps. PictureTel's Software Generation 3 (SG3) compression algorithm is utilized for video teleconferences with other USSOCOM units, and standards based px64 compression algorithm is utilized for conferences with other components. PictureTel M-8000 multi-point control units (MCUs) are located at USSOCOM Headquarters at MacDill Air Force Base, Florida; Fort Bragg, North Carolina; and the Pentagon to allow for multi-point teleconferencing. Each MCU is capable of connecting up to eight subscribers.

Data transmission between SCAMPI nodes is done over DS-1 and fractional DS-1 (FT-1) lines, leased by DITCO from MCI Government Systems. Voice, data, video, and imagery information are integrated into data streams using IDNX multiplexers. All information is encrypted using one or two levels by KG-194 COMSEC equipment. Video teleconferencing can be conducted at the SECRET collateral and SCI levels.

4. Global Command and Control System (GCCS)

GCCS is an evolving system that is the bridge to the DoD's Command, Control, Communications, and Computers for the Warrior (C4IFTW) objective. GCCS will eliminate stove pipe systems by providing an effective baseline for implementing the much needed C4I system consolidation and migration strategy. GCCS is not a hardware acquisition project and will be hardware independent. It will have standardized core operating equipment and provide core applications to achieve interoperability objectives (J6, 1994).

The primary mission of GCCS is to provide a global, flexible, and interoperable C4I system that is dedicated to supporting the warfighter. GCCS will reengineer and migrate legacy service command and control systems, as well as Worldwide Military Command and Control System (WWMCCS) applications which are required. WWMCCS functions will migrate to GCCS over the next two years, and these capabilities will be maintained until GCCS is fully operational and warfighters are satisfied with the results.

GCCS will be a Unix-based system, utilizing a client-server architecture. The Sun Microsystems SPARCserver 1000 will be the primary server, supporting common operating equipment (COE) which will include Unix servers, PC and Macintosh workstations. Videoconferences will be just one of the many applications that will be available over GCCS.

The Defense Information Systems Network (DISN) will provide the connectivity that will allow GCCS to function. The DISN is a planned nationwide synchronous optical network (SONET) that will utilize high speed asynchronous transfer mode (ATM) switches to achieve data transfer rates up to 2.4 gigabits per second.

5. Defense Simulation Internet / Theater Command and Control System (DSI/TCCS)

DSI was developed for DoD by the Advanced Research Project Agency (ARPA) and DISA, assisted by the Defense Modeling and Simulation Office (DMSO), to support real time distributed simulations. ARPA and DISA established the Advanced Information Technology Services Joint Program Office (AITS-JPO), which now manages the DSI. TCCS provides an information network of multimedia communications, trusted information processing, and global information repositories to support force level situation assessment, planning, and execution of joint operations (USCINCPAC, 1994). These two networks are discussed together because the TCCS uses the DSI backbone for connectivity to CINCs and other worldwide locations.

The primary goal of ARPA, DMSO, and DISA is to migrate the DSI into DISA's DISN architecture by 1995. With the DISN's planned initial backbone data rate of 45 Mbps, this network will be able to meet DoD's future demands in the area of distributed simulation. The DSI currently provides connections to approximately one hundred locations worldwide.

DSI's capability to transmit real-time data means it can support video teleconferencing using standard CODEC units. Most sites in the DSI are currently using the PictureTel 4000 series of video teleconferencing systems. These medium-sized systems are capable of

operating at data rates between 56 kbps and 384 kbps. Non-standards compliant CODECs may also be used, but will not interoperate with the PictureTel units at the low data rates (64 and 128 Kbps) needed to support multi-user VTC on the DSI. Multi-site VTC is possible by using "floor control" software which is provided with the VTC systems. Using floor control, all sites in a multi-site VTC see and hear transmissions from the one site that has the "floor" at any given point in the conference. The "floor" is controlled by a moderator site (DSI, 1994).

The DSI is capable of interconnecting multiple sites in a packet-switched mode. The DSI grew out of an ARPA Networking testbed known as the Terrestrial Widebandnet (TWBNet). The TWBNet was initially developed using DS-1 rate commercial circuits to form a cross-country backbone. The DSI backbone uses a unique advanced cellular switching scheme, similar to Asynchronous Transfer Mode (ATM). It is currently transitioning from a 3.1 Mbps backbone to a 6.2 Mbps backbone. The DSI also uses a new transmission security technique called end-to-end encryption (E3). The E3 security system works by only encrypting the data segment of each packet transmitted, leaving the address of each packet in the clear. This allows many users at different security levels to share unclassified information on the DSI.

6. Theater Area Command and Control Information Management System (TACCIMS) Video Support System Combined (TVSSC)

The TVSSC is a CINC Combined Forces Command (United States and the Republic of Korea (ROK)) theater-level command and control support system. The TVSSC is only fully connected for war, crises, and exercises. The TVSSC has a connection to the DSI in

addition to an analog gateway interface to the NAF Network (see Air Force Systems, this chapter). A future interface with the DCTN network is planned.

The wartime mission of the TVSSC is to enable CINC CFCs, component commanders, field army commanders and their equivalents to effectively command and control their forces. The peacetime mission of the TVSSC is to provide the CINC, CFC Staffs, components, field armies and their equivalents with an infrastructure to respond to contingencies; train for wartime deployment and employment using realistic battlefield simulations; and facilitate planning and integration between staffs and ROK agencies (USCINCPAC, 1994).

The TVSSC network is comprised of three smaller networks consisting of Command and Control (C2), 7th Air Force gaming and simulation subnetworks. The TVSSC interconnects multiple sites using CLI room-based video teleconferencing systems. Most CODECs are Rembrandt II/VP models capable of running CLI proprietary or standards based px64 compression algorithms. All TVSSC MCUs are older CLI Model 1 series and are not capable of being upgraded to comply with ITU-T standards.

TVSSC network links can operate at data rates from 128 kbps up to the DS-1 rate, over circuits leased through DITCO. During exercises fixed sites interconnected by fiber optic cable operate at the DS-1 rate, and sites interconnected by microwave operate at 512 Kbps. All network links are secured by KG-81, KG-94, or KG-194 COMSEC equipment. This equipment provides a SECRET-high VTC capability. (USCINCPAC, 1994)

B. U. S. ARMY SYSTEMS

1. Advanced Communications Technology Satellite (ACTS)

The ACTS system is a highly sophisticated next generation experimental communications satellite. It was launched by the National Aeronautics and Space Administration (NASA) in September of 1993, by the Space Shuttle Discovery. ACTS is a multi-beam digitally switched communications satellite system comprised of a flight segment, control segment, and ground segment. NASA coordinates access to and manages the system at the NASA Lewis Research Center in Cleveland, Ohio.

The ACTS system provides wideband technology with a capacity three times greater than current satellite technology. The system operates in the Ka-band of the frequency spectrum, and utilizes a high speed baseband processor (BBP) to effectively utilize its 1.544 Mbps transponder throughput capacity. Very Small Aperture Terminals (VSATs) provide the user with on-demand DS-1 rate connectivity in a single satellite hop. These terminals can interface with peripheral equipment such as STU-IIIs, commercial telephones, and video teleconferencing equipment.

The primary mission of the ACTS Program is to make the capabilities of the ACTS system available to the public and private sector (universities, corporations, government) for experimentation through NASA's Experiments Program. The Experiments Program coordinates the evaluation, validation, and demonstration of ACTS technologies in hopes of stimulating their use in future operational systems (Bauer, 1991).

Currently, the U. S. Army is experimenting with ACTS technologies to aid in their force projection operations. U. S. Army Space Command (USARSPACE) is the Army's

program manager for the ACTS system, and presently has seven VSAT earth terminals deployed in support of Operation Restore/Uphold Democracy in Haiti. These terminals are providing video teleconferencing support between military sites in North Carolina, New York, Colorado, and Haiti, using PictureTel System 4000 peripheral equipment. The VSAT earth terminals and the PictureTel System 4000 equipment are housed and transported in modular cases. Video teleconferencing can be conducted at data rates between 64 Kbps and 1.544 Mbps. The PictureTel System 4000 is capable of utilizing SG3 proprietary or ITU-T H.261 standards compliant compression algorithms. An ACTS terminal at Fort Bragg has been hard-wired into the installation's DCTN facility, giving forward deployed headquarters the capability to access over one hundred additional video teleconferencing studio facilities.

The ACTS systems uses a multi-beam antenna which operates in the Ka-band for transmitting and receiving, plus two electronically hopping spot beam antennas that provide coverage over the eastern and western United States. The BBP provides interconnectivity between spot beams in a single hop through the satellite. A multibeam communications package (MCP) receives, processes, switches, amplifies, and transmits communications signals using time division multiple access (TDMA) multiplexing. Data is burst to the satellite at 110 Mbps using serial minimum shift keying (SMSK) modulation. The satellites DS-1 throughput rate is dynamically allocated to user VSAT earth terminals in increments of 64 Kbps channels on-demand. The allocation of 64 Kbps channel allows the ACTS system to easily interface with ISDN basic and primary rate services.

The cost of a VSAT earth terminal is approximately two hundred and fifty thousand dollars, and varies depending on the quantity purchased. The Harris Corporation, has been

selected by NASA to build its VSAT earth terminals. Peripheral video teleconferencing equipment must be purchased separately from the earth terminal, which also varies depending on the type of system selected.

2. Teletraining Network (TNET)

The Teletraining Network is a fully integrated training network managed by the U. S. Army's Training Support Center at Fort Eustis, Virginia. TNET consists of over sixty sites throughout the continental United States (CONUS). The Army has worked with Oklahoma State University's Institute for Telecommunications to develop and test this satellite-based digital teleconferencing network over the past seven years. The network is currently in the process of expanding to include sixty new U. S. Air Force locations (Masud, 1994, p. 34).

The primary mission of TNET is to provide teletraining in a variety of topics to Army personnel stationed in CONUS. The system has been used extensively to reduce travel costs associated with training National Guard and Reserve units. The networks planned expansion to approximately 120 sites is an Air Force initiative to train their reserve units.

TNET sites utilize the VTEL Corporation's BK235 room-based video teleconferencing system. This system provides non-secure point-to-point and multipoint video, audio, document, and computer teleconferencing. The system is capable of operating at data rates from 56 Kbps to 1.544 Mbps. All VTEL systems are PC-based, software controlled systems which can run proprietary VTEL Blue Chip or ITU-T H.261 international standards compliant compression algorithms.

TNET uses the Hughes Corporation SBS-5 satellite system for transmission. The SBS-5 satellite operates in the Ku-band of the frequency spectrum. The SBS-5 has an

enormous throughput capacity, offering ten 43 Mbps channels, and four 110 Mbps channels, each utilizing a TDMA scheme and operating at up to twenty watts output power. Channels are allocated to customers commercially by Hughes Network Systems Division. The satellite offers coverage of all locations within CONUS and is capable of transmitting several sixteen site video teleconferences simultaneously.

3. Satellite Education Network (SEN)

The satellite education network is a distance learning network similar to TNET managed by the U. S. Army Training and Doctrine Command (TRADOC) at Fort Lee, Virginia.

The primary mission of the SEN is to provide logistics and acquisition support training to distant and/or remote locations. The SEN was used extensively during Desert Shield/Storm to provide language training to soldiers (Churchwell, 1994). TRADOC has also used the SEN to conduct logistics after action reports with units that were deployed in combat zones. These reports were recorded and rebroadcast to units deploying to the Persian Gulf region in order to prepare them for potential logistics problems (Welles, 1993).

The SEN has four studio systems and over 100 distant learning locations. The system is limited, providing one-way video and two-way audio over satellite paths.

4. Video Medicine

The U.S. Army is the recognized leader in the DoD in the field of videomedicine. Trippler Army Medical Center (TAMC) in Hawaii currently uses videomedicine to provide medical consulting and remote care to elements in the Pacific theater area of operations.

The primary mission of videomedicine is to extend medical services to distant beneficiaries, provide the ability to learn about various tropical diseases, select patients for training programs, and improve the ability of TAMC to conduct air evacuation and preparation of incoming patients. (LeBlanc, 1993)

TAMC uses a CLI Rembrandt room-based video teleconferencing system, operating at data rates from 56 Kbps up to the DS-1 rate. The system utilizes an RBII/VP CODEC using CLI's proprietary CTX Plus compression algorithm from application package four. TAMC also has a mobile facility that utilizes a CLI Eclipse portable system that can connect with the medical center by satellite or landline circuit (Churchwell, 1994). TAMC conducts all video teleconferences in the non-secure mode of operation.

TAMC is connected to the DCTN network at the DS-1 rate. Additionally, they have a dial-up capability of 128 Kbps using their CLI Eclipse portable VTC unit. This provides them with the ability to connect to the CLI MCU located at Hickam AFB, giving them access to the Pacific Air Force NAF network (see U.S. Air Force Systems this chapter).

The Army intends to remain in the forefront of video telemedicine. They recently adopted the use of a global telemedicine remote imaging and medical consultation system. This system is used to transmit still images, x-rays, and questions to remote locations allowing discussions of medical treatment strategies. The global telemedicine system has been used aboard the hospital ship USS Comfort in Haiti and at Army medical installations in Croatia, Bosnia, Macedonia, and the Rwanda-Zaire border.

The global telemedicine system includes a Macintosh Color DuoPowerBook and a Kodak DSC-200 digital camera. The digital camera downloads images to the Macintosh,

which compresses them for transmission using tools from Storm Technology Incorporated. (Masud, 1994, p. 34) Images are then transmitted via modem over the International Maritime Satellite (INMARSAT) system.

C. U. S. NAVY SYSTEMS

1. Video Information Exchange System (VIXS)

The Navy's VIXS network was designed to bring video teleconferencing to the Chief of Naval Operations (CNO), Fleet CINCS, and to some ships at sea. VIXS began in September of 1992 with a memo from Vice Admiral Tuttle tasking the Navy's Space Warfare Center (SPAWAR) to develop a CNO video teleconferencing network. The original idea was to connect the CNO, CINC U.S. Navy Europe (CINCUSNAVEUR) Naples and London, CINC Atlantic Fleet (CINCANTFLT), and CINC Pacific Fleet (CINCPACFLT). The Commander of U.S. Navy Central Command (COMUSNAVCENT) in Bahrain was added to the network in February of 1993. (Hamblen, 1994)

VIXS uses commercial components that provide SECRET-high video teleconferencing and reliable communications between CNO, Fleet Commander's in Chief and other users. SPAWAR conducted initial demonstrations and testing and concluded that PictureTel equipment would best fulfill this requirement due to its quality and resolution at lower bandwidths. Approximately three million dollars was appropriated for VIXS development. The end result is a cost-effective system that provides high-quality video in multi-point and point-to-point configurations.

The video teleconferencing systems are installed in three different PictureTel System 4000 configurations. They are the boardroom system Model 800, the roll-about system Model 400, and the desktop Model 200. The boardroom system is permanently installed and has two large monitors. The roll-about consists of a mobile cart and a single monitor. The desktop model is self explanatory. The CNO has the boardroom system. The Fleet CINCs use the roll-about systems. Ships approved for VIXS installation use models 200 and 400. The current plan is to have VIXS on each fleet flag ship.

VIXS can provide video teleconferencing capabilities between CINCs using a data rate of 256 kbps or greater. Video teleconferencing with Fleet units is conducted at data rates of 128 kbps or less. The network has a gateway to the DCTN using an analog bridge located at Hampton Roads, Virginia. VIXS uses KG-194 COMSEC equipment for network transmission security. The system uses the PictureTel proprietary SG3 compression algorithm when communicating with other PictureTel systems. The system is also capable of interoperating with other non-PictureTel systems using an ITU-T H.261 standards compliant algorithm.

Multipoint control units (MCU) are required for video teleconferences of three or more locations. The VIXS network utilizes the PictureTel M-8000 MCU. Multipoint control units are located at the Naval Telecommunications Center (NTCC) Hampton Roads, the NTCC Pearl Harbor, and the NCTAMS MED. Two ports on each MCU allow for cascading between theaters. The VIXS network allows for rapid shifting between data rates of 128 and 256 kbps as ships enter and exit the network. These bandwidth changes are done by a Timeplex Intelligent Multiplexer that has been installed at each shore site. These multiplexers are controlled by a TimeView 2000 network management system located at NTCC Hampton

Roads. VIXS is in the process of converting to NET's IDNX multiplexers, which are used by other services, as part of the near-term DISN architecture.

The VIXS network can operate over a variety of transmission mediums. These include commercial leased lines, SHF military satellite communications (DSCS), commercial C and Ku frequency band satellite communications, and the maritime satellite system INMARSAT. Which medium is chosen depends upon the situation. Video teleconferencing uses bandwidth that a ship might normally allocate for other things. There are trade-offs that exist, and they must be prioritized.

2. Challenge Athena II

Challenge Athena II is a CNO initiative to deliver high volume data to ships afloat. It was approved as part of a Congressional Intelligence for Targeting initiative to work toward correcting targeting deficiencies recognized during Desert Storm. Challenge Athena is currently being tested afloat on the USS George Washington. The system uses twenty two C-band International Telecommunications Satellites (INTELSAT) channels with 32 kbps data rates. A 2.4 meter INTELSAT antenna mounted on the ship provides satellite access. Plans call for the system to be installed on all CV's, LHD's, and Command Ships by the year 2000. (OSO, 1994)

The primary mission of Challenge Athena II is to deliver high volume data capacity to U.S. Navy ships afloat. This data capacity is inverse multiplexed at the ship, providing tactical imagery, circuit switched phone service, and video teleconferencing capability.

Video teleconferencing is accomplished using PictureTel series 4000 equipment, identical to the equipment used with VIXS. A Timeplex inverse multiplexer can allocate up to 128 kbps of ship bandwidth to video teleconferencing using the VIXS system.

The cost of operating the Challenge Athena system is moderate. INTELSAT 32 Kbps channels cost a flat rate of forty-eight dollars per month. Long distance calls are billed based on volume, averaging approximately one dollar per minute.

3. Octopus Network

The Octopus Network is a closed, desktop-based video teleconferencing and data network with sites at the National Military Intelligence Center (NMIC) Suitland, Maryland, Office of Naval Intelligence (ONI) elements in the Pentagon, the National Security Agency (NSA), U.S. Atlantic Command (USACOM), and U.S. Pacific Command (USPACOM). The NMIC serves as the hub station in the network. (Bowser, 1994)

The primary mission of the Octopus Network is to provide multimedia connectivity to Office of Naval Intelligence organizational elements. Octopus operates at the TOP SECRET-SCI level, and is interoperable with JWICS by virtue of the fact that both systems use the same CODEC (RBII/VP). The Octopus network will most likely be phased out once JWICS is fully deployed and implemented in fiscal year 1996.

The Octopus Network is comprised of Datapoint Corporation's MINX 2000 and 2002 work stations. Each workstation consists of a color monitor, built-in color camera, speaker, and a microphone. These work stations are connected to Compression Labs Rembrandt II/VP CODECS running application package three CLI proprietary CTX Plus compression algorithms. Timeplex Link2 multiplexers utilize time division multiplexing to combine

workstation outputs into composite data streams for transmission over DS-1 site interconnections, leased through DITCO. A Timeplex TimeLan-100 provides routing and bridging capability into Joint Maritime Command Information System (JMCIS) and GCCS at the hub station located at the NMIC.

The cost of video teleconferencing using the Octopus network is comparable to DCTN. Typically, costs are high because services are paid for based on availability, not usage.

4. Chief of Naval Education and Training Electronic Schoolhouse Network (CESN)

CESN is a video teletraining network sponsored by the Chief of Naval Education and Training (CNET) Office. CESN sites are currently in operation at eleven naval bases in CONUS, with hub stations located in Dam Neck, Virginia and San Diego, California.

The primary mission of CESN is to provide professional development courses to all Navy personnel to assist in furthering their education and advancement in rank. The Navy currently offers two dozen courses over the network that cover a broad range of topics from shipboard security to total quality leadership fundamentals.

CESN utilizes the VTEL Corporation's room-based BK235 family of video teleconferencing equipment. These classroom PC-based systems are comprised of a Mediamax CODEC, three forty-inch color monitors, two pan/tilt/zoom cameras, twelve microphones, a document camera, a laser facsimile machine, and a remote control. These systems are leased from VTEL on an annual basis.

CESN uses AT&T's FTS-2000A long distance carrier service, which provides full duplex video and audio connectivity. Fractional DS-1 rate service is provided twenty four hours a day, seven days a week at rates up to 384 kbps. Videoconferences can be conducted up to the TOP SECRET level using KG-194 COMSEC equipment.

The cost of video equipment annual leases averages 65,000 dollars per CESN site. Total operating costs are less than one million dollars per year, saving the Navy an estimated two million dollars over the past five years in travel costs. This is a very cost effective method of conducting distance learning.

D. U. S. AIR FORCE SYSTEMS

1. Program Executive Office Networks (PEO Nets)

PEO video teleconferencing networks are used by the Air Force to assist in the management of major acquisition programs. PEO offices in the Pentagon use video teleconferencing to manage high profile programs such as the B1-B Bomber, the F15, and the C-17 aircraft. These are open networks that connect to various industry and government locations that are involved in the procurement, construction, and management of these programs.

PEO networks predominantly use PictureTel System 4000 peripheral equipment. The model 200 roll-about system is the unit most widely used. PictureTel's proprietary SG3 compression algorithm is used, but each system is capable of operating using standards compliant H.261 compression software when interfacing with non-PictureTel equipment. Video teleconferencing is primarily conducted without transmission security, however, some

locations utilize Data Encryption Standard (DES) algorithms for security. DES was adopted by the U. S. government in 1976 for encryption of all non-classified communications (Khan, 1994). DES is an optional feature offered with all PictureTel systems.

The networks utilize Sprint's FTS-2000B as its' transmission medium. Switched-56 service is contracted through DITCO at Scott Air Force Base, Illinois. DITCO provides consolidated billing to individual locations monthly based on usage. Videoconferences are conducted at data rates of 112 kbps.

Costs are based solely on usage. Flat monthly fees of approximately fifty dollars are charged for the switched-56 service, with usage rates running approximately one dollar per minute. These rates go down however, the more the service is used.

2. Numbered Air Force (NAF) Network

The NAF network is a SECRET-high video teleconferencing system that supports video communications between Headquarters Pacific Air Force (HQ PACAF), and other NAFs located at Yokota Air Base, Japan (5th AF); Osan Air Base, Korea (7th AF); Elmendorf Air Force Base, Alaska (11th AF); and Andersen Air Force Base, Guam (13th AF).

The primary users of the NAF Network are staff elements at HQ PACAF and the NAFs (USCINCPAC, 1994). The network is used for operational, administrative, and logistics planning and operations. Plans are currently under way to expand this network as a backbone for migrating older "stovepipe" legacy systems into a Pacific VTC Network.

The five NAF Network studios use older CLI room-based video teleconferencing equipment. These systems utilize the Rembrandt II/VP CODECs running px64 standards

based compression algorithms. These systems are also capable of running CLI's proprietary compression software CTX Plus, to interface with older model Rembrandt systems at some DCTN studio locations.

NAF Network sites are interconnected by leased 128 kbps circuits. An MCU located at Hickam Air Force Base, Hawaii can support multi-point teleconferencing. This MCU, an older CLI Model 1, is not standards compliant and cannot be upgraded to be px64 compliant. The network is secured by KG-81 COMSEC equipment.

Yearly circuit leasing and video teleconferencing costs are estimated at approximately $75,000 per circuit. Total costs are less than one million dollars per year.

E. U. S. MARINE CORPS SYSTEMS

The Marine Corps Video teleconferencing (MCVTC) project was established in 1994, as part of the Marine Corps Computer and Telecommunications Activity (MCCTA) in Quantico, Virginia. MCVTC locations include the Navy Annex, Headquarters Marine Corps, Marine Corps Base Quantico, and the Marine Corps Tactical Software Support Activity (MCTSSA), Camp Pendleton, California. MCVTC studios are part of the DCTN network, connected at the 384 Kbps sub-rate. Plans exist for future video teleconferencing sites at Marine Corps Logistics Bases in Albany, Georgia and Barstow, California. (Gaudreau, 1994)

III. INTEROPERABILITY ISSUES

Many factors affect the interoperability of video teleconferencing systems in the Department of Defense. Video teleconferencing was never formally recognized, tasked, or funded as a DoD program until DISA was given the task in October 1993. Prior to this date, DoD's approach to video teleconferencing had been as a service (DCTN for example), not as a system. In addition, requirements for video teleconferencing capabilities began to change from administrative support to providing real-time operational support to the warfighter. These requirements, with no formal program in place, caused users (CINCs) to proliferate their own video teleconferencing networks, which as might be expected are mostly non-interoperable.

VTC interoperability can be divided into two distinct areas; customer premise equipment (CPE) and the network to which the CPE is attached. CPE is composed of an end-system such as a computer, telephone, or a video teleconferencing system. Network services are provided to a point of presence (POP) by the telephone company. The network used for video transmission is responsible for the majority of interoperability problems that exist today, but is the hardest to solve. CPE on the other hand, is easily solved by upgrading existing equipment or by new purchases. This chapter examines these interoperability issues in depth, and attempts to shed light on the most common interoperability problems found in the systems discussed in Chapter II.

A. CUSTOMER PREMISE EQUIPMENT (CPE)

To resolve the lingering interoperability problems between different manufacturers of video teleconferencing systems, the ITU-T (formerly CCITT) approved the H.320 family of video teleconferencing standards. This family of standards addresses CODEC compression standards and data transmission rates, two of the most important system interoperability considerations. Even with the acceptance of the H.320 family of video teleconferencing standards, at least a dozen incompatible video teleconferencing technologies are still on the market.

CPE is defined as any equipment purchased by the user. In other words, equipment not provided by the network from which services are purchased. CPE interoperability problems can be divided into three sub-areas; the compression algorithm, the data rate, and transmission security.

1. Compression Algorithms

It takes an enormous quantity of bandwidth to supply full-motion video across a network. A full screen point-to-point video teleconference running at 30 fps can consume over 220 Mbps of bandwidth, far too great a capacity for today's LANs, digital phone lines, and personal computer (PC) I/O buses. Reducing frame rates or image sizes is not enough to solve this problem. It is necessary to compress each frame prior to transmission and restore it at its destination. This requires data compression hardware which is usually integrated into a motion-video card, CODEC, or PC motherboard.

The majority of video compression techniques work by eliminating the parts of an image that have not changed since the last frame. Digital video often suffers from

inconsistent picture quality and fluctuating frame rates, because compression ratios and bandwidth requirements depend on the content of each image. But this problem is normally mitigated for video teleconferencing, which primarily relies on static "talking-head" shots (Labriola, 1994). There are a variety of common video teleconferencing compression standards that allow for the transmission of digital video across a network. These range from proprietary compression algorithms to a set of emerging industry standard algorithm. They include ITU-T Recommendation H.261 (px64), one for photo-quality still images developed by the Joint Photographic Experts Group (JPEG), and two for full motion images developed by the Motion Pictures Experts Group (MPEG). These algorithms all have in common the use of the discrete cosine transform (DCT) signal processing technique to compress video at ratios from 20:1 to 200:1. The actual compression rate depends on whether lossless or lossy techniques are used.

H.261, also referred to as px64, is the first internationally accepted standard for video teleconferencing compression. This standard was approved in 1990, and works at transmission speeds from 56 kbps to 1.920 Mbps on ISDN channels, in increments of p times 56/64 kbps. For an in depth discussion of H.261, see Chapter IV.

Motion JPEG is an enhancement to the popular still-image compression standard developed by the International Standards Organization (ISO) Joint Photographic Experts Group. This standard compresses live video with high quality results, but can only provide moderate amounts of compression (20:1 to 50:1).

The MPEG-1 compression standard was originally intended for the delivery of video on compact disc. MPEG-1 achieves compression ratios of about 50:1, by using lossy

methods that store only the differences between successive frames. Decoded images are expanded to fill a television screen, producing an image quality similar to video home system (VHS) half inch tape format. MPEG-2 is a standard for the compression of broadcast television images (National Television System Committee (NTSC) United States standard and Phase Line Alteration (PAL) European standard) into a 4-8 Mbps data stream consisting of three elements: video, audio, and system. It also defines a syntax for compressed audio and a mechanism for combining and synchronizing the video and audio elements into a single data stream (Feige, 1994). MPEG-2 is capable of decoding MPEG-1 images, is extensible to high definition television, and allows compression ratios up to 160:1.

The important interoperability consideration is that whatever compression standard is used at one end of a video teleconference must be used at the other end. Otherwise, the only way to bridge two video signals using two different compression standards is by using a gateway. This gateway must have CODECs capable of using both compression standards, decode incoming signals, and re-encode them for compatible transmission to the distant end. Gateways with such capabilities are few, and expensive. DISA recently opened a Level II Network Management Facility in Columbus, Ohio offering these capabilities, as part of the DISN near-term architecture. But the cost is high. Services cost between $75 and $150 per month based on the service provided, plus an additional $0.75 to $1.10 per minute for bridging fees. There is an additional $350 per month charge to allow DISA to recoup the money it spent to establish the facility. Sprint and AT&T also operate conversion gateways. The Sprint Meeting Channel and AT&T Gateway Services can provide a variety of CODEC, speed, point-to-point, and multi-point conversions at data rates between 56 kbps and 384

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kbps, in the non-secure mode of operation. These services are not available for secure operation. These services are also expensive, averaging $0.75 per minute at 128 kbps to $1.75 per minute at 384 kbps.

Unfortunately, monolithic devices capable of handling all of these standards are still in the development stage. When they do become available, they will be expensive until the price of manufacturing them can be decreased.

2. Data Rates

The rate at which video data is transmitted across a network to a distant-end subscriber must be the same at both ends of the connection. Video teleconferencing system CODECs are capable of operating between 56 kbps and 2 Mbps, but are limited by the network the data is transmitted across. This phenomenon is caused by the cost of transmission using a public or private network. Cost is directly associated with the amount of bandwidth used. The higher the bandwidth utilized, the higher the cost. Therefore, most network services are purchased at less than maximum bandwidth capacity, and thus limit the speed at which a CODEC can transmit compressed video data.

The data rates are purchased in p=n times 56/64 kbps allocations (thus the standard px64), where n can be between 1 and 30. These allocations are reduced to 56 kbps channels if analog switching using in-band signaling is involved in the transmission path. The data rate, (switched 56 kbps service) must be the same at both ends of the video teleconference to ensure compatibility. If not, then some type of bridging facility or gateway must be used to "step-down" the higher-speed signal. A case in point was the interoperability problem between FTS-2000's Network A and Network B. AT&T's Network A could not video

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teleconference with a fully compatible system using Sprint's Network B because they operated at different data rates. Sprint resolved the problem in January of 1994 by dropping its 768 kbps transmission rate to 384 kbps, the same as Network A (Morgan, 1994). The General Services Administration, which supervises the FTS-2000 contract, approved the contract modification and allows Sprint to operate a gateway between the two networks.

3. Transmission Security

The government's security needs also fall into either the customer premise equipment (CPE) environment or the communications network (CN) environment that connects the CPEs. Communications networks fall into two categories: a carrier-controlled public infrastructure or a public-controlled private lines and switches. Transmission security is required for both environments, but today most transmission security is implemented in the CPE environment, sometimes referred to as end-to-end or "link" encryption. Two methods of implementation in use are bulk encryption for classified information and Data Encryption Standard (DES) for unclassified but sensitive information.

Bulk encryption is accomplished by placing communications security (COMSEC) equipment between the local subscriber equipment and the communications network. The "KG" family of controlled cryptographic items (CCI) such as the KG-81, KG-94, and KG-194 are predominantly used for bulk encryption of composite audio and video data streams. This equipment when used in conjunction with the appropriate keying material, is approved by the National Security Agency (NSA) to operate up to the TOP SECRET/SCI level of classification. DCTN, ACTS, VIXS, and other DoD video teleconferencing systems utilize this type of equipment for end-to-end encryption.

DES algorithm software implementations are available as purchase options with most video teleconferencing systems. DES was adopted by the U.S. government in 1976 for encryption of all non-classified communications (Khan, 1994). DES has been widely implemented in government, business, and the banking industry for the protection of sensitive data. DES encrypts all types of files, whether for storage or transmission. The National Institute for Standards (NIST), using Federal Information Processing Standard (FIPS) 46-2, has validated four DES software implementations and is evaluating six more at the present time. The Air Force's PEO video teleconferencing networks that transmit sensitive data utilize DES encryption, purchased as an option with their PictureTel systems.

Currently, there is no true "network" security implementation. Multi-point secure video teleconferences are conducted by using closed network, reservation based calls, which defeats the purpose of a network. Network subscribers need the flexibility to make spontaneous calls, discuss ideas, and formulate solutions. Current network architectures do not support this kind of spontaneity, secure or non-secure. For a more detailed discussion of transmission security, see Chapter VI of this document.

B. NETWORKS

The network used for transmitting video teleconferences presents the most difficult interoperability problem. This problem can be traced to the individual services emphasis on systems that support their own private networks, at a time when DoD technical leadership was absent. Examples include DCTN, SCAMPI, CESN, NAF Net, OCTOPUS Net, and many other closed networks that are in use. Network interoperability is the key to overall interoperability, and should be where DoD's attention is focused first, not on the system itself.

System interoperability problems involve CPE, and are generally problems that are the responsibility of the user. With the mandate from the Office of the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (OASD(C3I)) that all existing VTC systems be upgraded to comply with the Corporation for Open System International (COS) VTC Profile, CPE level interoperability problems are beginning to disappear. But network interoperability problems are more insidious and more costly to resolve.

DoD has recently begun adopting a more network oriented approach to video teleconferencing interoperability issues. Last year DoD formed an alliance with the Corporation for Open Systems International (COS), a consortium of telecommunications providers and users. DoD working with COS has reached an agreement on a COS video teleconferencing profile, which is applicable to both government and industry in the acquisition and operation of video teleconferencing equipment. This profile was approved in July 1994, and covers point-to-point video teleconferencing standards for data rates between 56 kbps and 1,920 kbps (see Chapter IV). This new open systems approach should eliminate the proliferation of additional stove pipe networks by individual services.

The question remains how best to proceed with the networks that currently exist. Today, DoD video teleconferencing uses purchased or leased circuit switched technology over the public switched telephone network. The majority of leased circuits are used to form private, closed networks that impede interoperability. In addition, packet switched technology that supports video teleconferencing is beginning to appear on the market. Standards for multi-point video teleconferencing still do not exist, but are expected to be approved this year.

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Solutions must be implemented not only to make the current circuit switched video teleconferencing services that exist today interoperable, but plan for future technology that will allow virtual private networks to pass video teleconferences using packet switching. Today we can pick up a telephone and seamlessly place a call without regard to equipment, network, or service providers. Video teleconferencing should be just as simple.

1. Circuit Switched Video

DS-1, Fractional DS-1, and FTS-2000 are simply plain old telephone service (POTS). This is more commonly known as circuit switched telecommunications over the public switched telephone network (PSTN) in increments of 56 Kbps or 64 Kbps. All video teleconferencing within DoD except for the Defense Simulation Internet is currently operating using this form of transmission. However, the PSTN is not well suited for multipoint communications. This technology was designed for point-to-point voice and data communications, and is being adapted to work with video teleconferencing. Circuit switched communications works well for closed networks conducting point-to-point video teleconferences. However, multi-point video teleconferencing necessitates the introduction of human interface, bridges, and gateways. The difficulties in conducting multi-point video teleconferences between AT&T's FTS-2000A Compressed Video Transmission Service (CVTS) and DCTN Network are a perfect illustration of this point. Subscribers to AT&T's CVTS must use Sprint's Meeting Channel as a gateway to interconnect the two networks. However, CVTS users are limited to teleconferencing with only one DCTN studio at a time. Since there are over 140 DCTN video teleconferencing studios, one or more at virtually every CONUS military installation, this is a severe limitation.

On the other hand, new services such as ISDN and Switched 56 kbps digital service, which are also circuit switched telecommunications, are well suited for open network architectures. Subscribers of this service can conduct point-to-point or multi-point video teleconferences using dialing interfaces similar to home telephones and multi-point control units, with little intervention. But ISDN and Switched 56 Kbps are not offered as a service from DISA's current Defense Switched Network (DSN) contract. This has driven users to lease circuits and promulgate their own closed networks.

2. Packet Switched Video

Packet switched video is being utilized on the Defense Simulation Internet, and is planned for the Global Command and Control System. Other government agencies such as ARPA have worked with video over the Internet using multicast backbone (MBONE). However, traditional local area networks (LANs) were not designed with the transmission of video in mind, and many problems still exist.

Traditional LANs are designed to provide error free transmission. But most video teleconferencing applications can tolerate some errors in transmission due to corruption or packet loss. With video teleconferencing, in order to meet real time delivery requirements or to achieve synchronization, some packets may even be discarded. Consequently, we may apply less rigorous, if any, transmission protocols to packet switched video teleconferencing networks. Such transmission protocols are still in their development stage.

Express Transfer Protocol (XTP) is one such protocol. The U.S. Navy has done research and development with XTP over its Survivable Adaptable Fiber-optic Embedded Network (SAFENET) for several years (Buddenberg, 1994). XTP could very well be the

next generation protocol that provides these types of services which transmission control protocol (TCP) cannot. Several of these services are critical to combining data and voice/video onto a single communications substrate and set of protocols.

C. NETWORK ENHANCEMENT

As stated earlier, DoD has began to focus its attention on the network, and how to best to improve it. Until packet switched video technology is widely available, circuit switched video will remain the DoD standard for video teleconferencing. Two options are presently being pursued by DoD to enhance the interoperability of video teleconferencing: the Network Enhancement Program (NEP) and upgrading the Defense Switched Network (DSN) to include switched digital service.

1. Network Enhancement Program II (NEP II)

The DCTN NEP II is an upgrade to the DCTN network primarily designed to allow low bit rate video (LBRV) subscribers access to the DCTN network. LBRV being 112 kbps to 384 kbps. LBRV subscribers would be bridged into the DCTN network by a video network management center (VNMC) in Columbus, Ohio.

DISA contracted AT&T to build the VNMC in Columbus, Ohio at a cost of over one million dollars. The VNMC would provide variable bandwidth access (112 - 384 Kbps) to the DCTN network. It is a CODEC independent operation, having the ability to accept subscribers with all types of CODECs running different compression algorithms. Most importantly the VNMC can support CODECs running proprietary algorithms. The center can support point-to-point as well as multi-point video teleconferencing. Lastly, it offers a secure

capability, from Confidential to Top Secret. The DCTN NEP II also features usage sensitive billing. In other words, you are supposed to pay for only what you use as a LBRV subscriber. It can provide switched or dedicated access. However, NEP II LBRV service is only available in CONUS. The VNMC became operational in December of 1994.

LBRV subscribers and potential subscribers are quickly realizing that NEP II falls short of its promised abilities. To understand how, we must first look at the fees involved in subscribing to LBRV. DCTN LBRV access costs $90.00 per month. If you want secure multi-point capability, add another $88.00 per month. In addition, there is a $350.00 surcharge per month for the Defense Business Operating Fund (DBOF) to recoup its cost of building the VNMC. This totals to $528.00 per month, and a single call has yet to be made (Kinder, 1994). Now we must add transport, bridging, and secure multi-point fees. Transport fees average $0.60 per minute from the nearest point of presence (POP), bridging fees are $0.60 per minute, and secure multi-point fees are $1.32 per minute. Conservative use (2 hours per day, 40 hours per month) of an LBRV subscription would cost in excess of $6000.00 per month. These figures are calculated at 112 kbps access, and are higher for access at 384 kbps. This high cost appears to defeat the purpose of allowing LBRV users into the network. The main reason a subscriber is a LBRV user to begin with is because they cannot afford the cost of a DCTN studio, approximately $13,000 per month to operate.

If we compare the cost of DCTN LBRV to the cost of switched compressed video transmission service (SCVTS) over FTS-2000, difference in cost is easy to see. Conservative use (40 hours per month) of a dial-up VTC system using FTS-2000 SCVTS service costs approximately $700.00 per month, running at 112 kbps. The same forty hours of video

teleconferencing using DCTN LBRV service costs approximately $2100.00 per month running at 112 kbps. That's a three to one cost difference for a higher data rate over FTS-2000.

The most disturbing factor of the NEP II upgrade is that it does not allow FTS-2000 users to access the VNMC and LBRV subscription services. As an FTS-2000 user, a special AT&T LBRV long distance carrier subscription must be purchased. This long distance service is not compatible with FTS-2000. So, if an FTS-2000 user currently conducting dial-up video teleconferences with other FTS-2000 users subscribes to DCTN LBRV service, they not only pay more, but lose capabilities in the process. This is only half of the story. Each and every DCTN studio that an LBRV subscriber wishes to video teleconference with must incur a one-time $700 multiplexer upgrade, pay an additional $185.00 recurring cost for the service, and pay the $350.00 per month for the DBOF to recoup its initial investment.

The DCTN NEP II is a good idea poorly executed. Between January and April 1995, the VNMC had placed a total of thirty video teleconferences including testing connections (about 1-2 per week), and it is not hard to see why. The DoD needs a true dial-up video teleconferencing ability on-demand. NEP II was to plant the seeds of such a capability, but fell far short. The technology for on-demand dial-up video teleconferencing is here, and many customers such as Air Force PEO offices are using it. However, these customers continue to not have access to the DCTN network due to a poorly written NEP II contract. These customers can only wait until March 1996, when the DCTN contract with AT&T expires, and see what the future brings.

2. Defense Switched Network

The Global DSN is the principal long-haul, voice communications network of the DoD. It provides worldwide, direct distance dialing station to station service through a system of government owned and leased switching and transmission facilities. Global DSN currently consists of 30 switches in CONUS, 12 switches in Europe, 15 switches in the Pacific, four in South West Asia, eight in Canada, one in Alaska, and one in Panama. (AT&T, 1994)

The purpose of the DSN is to provide rapid, worldwide, command and control communications for the National Command Authority (NCA) and other high priority users. Its secondary mission is to provide a routine administrative service for the operational, intelligence, logistic, operations support, and diplomatic users.

However, switched digital service is not available on the DSN. It is easy to see that if switched digital service were available, it could solve one of the biggest drawbacks with the DCTN network today, an OCONUS long-haul capability. Besides the overseas long-haul capability, the DSN is already in use down to the tactical level. This fits right in with today's video teleconferencing paradigm shift from administrative support to operational support to the warfighter.

D. STANDARDS

Standards are the key to interoperability. When everyone uses the same set of rules, interoperability problems become isolated incidences that can be dealt with individually. However, the technology continues to advance so rapidly in the field of video teleconferencing, that is hard for standards to keep up, let alone define a strategy for the

future. The DoD's approach to standards has recently been drastically altered by the Secretary of Defense, and may improve the government's ability to keep pace with commercial technology. Chapter IV discusses these standards and their impact.

IV. DISCUSSION OF STANDARDS

This chapter provides an in-depth look at the standards which shape video teleconferencing within DoD. It is applicable to anyone involved or interested in the tools for defining interoperability of VTC systems. To establish a common baseline for all readers, the chapter begins with an introduction of the concept of standards. Subsequently, the important standards making bodies are identified followed by highlights of their products which impact the current state of video teleconferencing in DoD. Next, a chronological explanation of how DoD arrived at its present position with respect to VTC standards is presented. Finally, a glimpse of standards expected to influence the future of VTC is offered.

A. CONCEPT OF STANDARDS

The main purpose of standards is to promote interoperability. Through improved portability and scalability of products, standards also contribute to reduced costs in procurement life cycle, maintenance, and upgrades. Standards encourage competition and facilitate adoption of product improvements. They also provide consistent user interfaces which aid in assimilating new features. Compliance with standards decreases risk, both on the part of manufacturers and consumers. By virtue of standards, consumers can be confident that products they purchase will interoperate in the market place with past, present, and future standards compliant products from any manufacturer. (DISA, 1995)

Standards are essential in our technological world. However, potential problems exist with standardization, especially in rapidly evolving technologies such as telecommunications. Standards, like the technologies they govern, must evolve. If they do not, the very

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capabilities they intend to regulate will stagnate, become unattractive to users, and fall into disuse as consumers upgrade to more functional, proprietary products. Periodic revision to incorporate technological advances is imperative. Standards, therefore, must be carefully crafted to assure an acceptable level of interoperability today while facilitating insertion of tomorrow's enhancements. Standards must also be timely. Delays in production of recommendations, further exacerbated by the pace of technology, will render standards obsolete by the time they finally get published. There is also the issue of conflicting standards from different organizations. When conflicts occur, users find themselves divided into camps supporting one standard or another. The promise of interoperability is lost. Contemporary examples of conflicting or competing standards include VHS versus Betamax video tape format, IBM versus Apple personal computers, and the new double sided CD-ROM format conflict between Sony-Phillips and Toshiba-Pioneer.

Fortunately, the standards which apply to VTC have apparently eluded the potential pitfalls described above. The standards discussed in this chapter provide upgradability; were published in a timely manner; and do not conflict with other standards. The result is equipment available from several manufacturers capable of multiple modes of operation that support not only the accepted international standard, but one or more proprietary modes as well.

B. STANDARDS MAKING BODIES

There are many organizations which produce standards. They exist at the international, national, and professional levels. Many of these organizations interact by working jointly to establish standards or by adopting and redesignating existing standards

from other organizations. To better acquaint the reader with the global standards community in general and the portion of that community which focuses on VTC, the following sections will introduce the major standards making bodies.

1. International Telecommunication Union (ITU)

The ITU is a major sub-element of the United Nations' Economic and Social Council. The ITU consists of three main branches, the Radiocommunication Sector, the Telecommunication Standardization Sector, and the Telecommunication Development Sector.

The Telecommunication Standardization Sector, abbreviated ITU-T, is responsible for publishing the recommendations that address video teleconferencing. The ITU-T receives its mandate from the World Telecommunication Standardization Conference (WTSC), which meets every four years and presents the ITU-T Study Groups with topics for research. The ITU-T then produces recommendations based on those topics. (ITU-T H.320, 1993, Forward)

2. International Organization for Standards (ISO)

The following excerpt from ISO's World Wide Web home page (http://www.iso.ch) describes the ISO and clearly explains its mission.

> The International Organization for Standards (ISO) is a worldwide federation of national standards bodies from some 100 countries, one from each country. ISO is a non-governmental organization established in 1947. The mission if ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity.

ISO's membership is classified into three groups: member bodies, correspondent members, and subscriber members. Member bodies are national-level standards making bodies and, as such, are the sole representatives from their respective countries in the ISO

General Assembly. Correspondent members are from countries which lack a full-fledged national standards activity, but wish to stay abreast of international standards work. Subscriber members are from economically small countries with a lesser stature than correspondent members. (Makato, 1995)

3. American National Standards Institute (ANSI)

ANSI is the United States' representative to ISO. ANSI is a private, non-profit organization responsible for coordinating the voluntary standards system in the United States. ANSI's membership includes approximately 1,300 American and international companies; 250 professional, technical, trade, labor, and consumer organizations; 30 U.S. Government agencies; and 20 institutional members. (Berg, 1995)

4. National Institute for Standards and Technology (NIST)

Formerly known as the National Bureau of Standards, NIST is an element of the United States Department of Commerce. NIST is charged with developing standards which apply to the entire federal government. The NIST standard which applies to VTC is Federal Information Processing Standard Publication (FIPS Pub) 178. FIPS Pub 178 merely adopts the ITU-T H.320 family of standards for use by the U.S. federal government. (NIST, 1993)

5. Bandwidth On Demand Interoperability Group (BONDING)

BONDING is an industry consortium made up of equipment manufacturers and communications carriers. The BONDING standard addresses the division of one high-capacity data stream into several 56 or 64 kbps circuits and their subsequent re-aggregation at

the distant end. The BONDING standard has been submitted to ANSI and ITU-T for adoption as recommendations by both of those organizations.

6. Motion Picture Experts Group (MPEG)

MPEG is the nickname of an ISO working group tasked with developing standards for motion video. The official title of the working group is ISO/IEC JTC1 SC29 WG11, which translates to International Organization for Standards/International Electro-technical Commission Joint Technical Committee 1, Sub-Committee 29, Working Group 11 (moving pictures with audio). (Filippini, 1995)

7. Corporation for Open Systems International (COS)

The Corporation for Open Systems International was founded in 1986 with 17 member groups and a primary mission to test systems for conformance to the Open Systems International (OSI) architecture. Today there are over 39 members, including computer vendors, communications providers, and users from government and industry. Despite the group's composition, which may suggest conflicts of interest in promoting proprietary protocols, COS maintains a neutral stance and uses the diversity of its membership to keep users abreast of trends in industry and to keep industry in touch with users' requirements. COS's purpose is captured in its mission statement, which was revised in May 1992 to read,

> Accelerate the implementation, deployment and usage of standards-based, interoperable, open systems networking products and services.

The COS contribution to video teleconferencing standards was produced by COS's VTC Executive Interest Group (EIG) and is entitled "COS Video Teleconferencing Profile." (COS Profile, 1994)

C. THE STANDARDS

There are a great number of standards which impact on VTC either directly or indirectly. Rather than explore each and every standard in the VTC realm, this section concentrates on the standards most important to the DoD video teleconferencing community. These standards are presented in the following table.

Organization	Standard	Title
ITU-T	H.320	*Narrow-band Visual Telephone Systems and Terminal Equipment*
ITU-T	H.221	*Frame Structure for a 64 to 1920 kbit/s Channel in Audiovisual Teleservices*
ITU-T	H.230	*Frame Synchronous Control and Indication Signals for Audiovisual Systems*
ITU-T	H.242	*System for Establishing Communication Between Audiovisual Terminals Using Digital Channels Up to 2 Mbit/s*
ITU-T	H.261	*Video CODEC for Audiovisual Services at p x 64 kbit/s*
BONDING		*BONDING Standard*
COS	VTC001	*COS Video Teleconferencing Profile*

Table 1. Standards to be Discussed

For those interested in examining the full text of the standards discussed here, Appendix C provides information for obtaining documents from the responsible standards making bodies.

1. ITU-T Recommendation H.320 *Narrow-band Visual Telephone Systems and Terminal Equipment*

H.320 is ITU-T's umbrella standards document for VTC at data rates between 56 kbps and 1,920 kbps. It accomplishes the following tasks:

- defines a vocabulary for discussion of VTC

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- assigns other ITU-T standards to various VTC system components

- classifies types of signals used in a video call

- defines modes of operation in terms of channel rate and audio coding scheme

- defines operational characteristics of different terminal types in terms of modes of operation

- describes the phases of a video call

- introduces the need for delay in the audio path to achieve lip synch

- introduces Control and Indication (C&I) signals

- outlines requirements for intercommunication with visual and non-visual telephone instruments

- describes a system self-diagnostic maintenance capability

- discusses the interface between the human operator and the equipment (man-machine interface (MMI))

(ITU-T H.320, 1993)

Figure 1 shows the generic VTC system presented in H.320. The diagram is appropriately labeled with the ITU-T Recommendations applicable to the various items of equipment or functions which make up the VTC system.
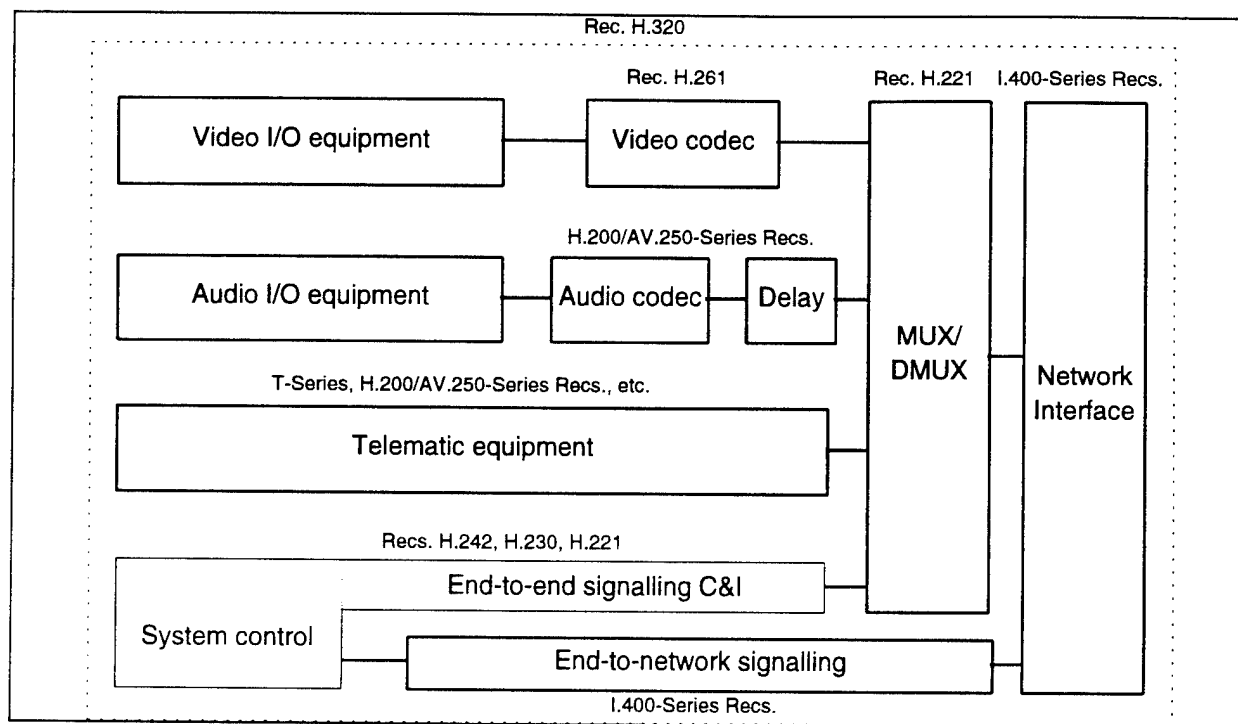
Figure 1. Generic VTC System. (From ITU-T H.320, 1993, p. 2)

2. ITU-T Recommendation H.221 *Frame Structure for a 64 to 1920 kbit/s Channel in Audiovisual Teleservices*

H.221 describes the frame format for video at data rates between 64 and 1,920 kbps. It defines the frame structure over several different configurations of transport media, including single and multiple ISDN B (64 kbps) channels, single and multiple H_0 (384 kbps) channels, H_{11} (1,536 kbps) channels, and H_{12} (1,920 kbps) channels. Essentially, H.221 defines how the data resulting from a video teleconference, which includes video, audio, computer data, and control information, is to be multiplexed together for transmission to the distant end and then demultiplexed into its constituent parts. (ITU-T H.221, 1993, pp. ii-1)

The basic idea is to view the data channel, regardless of the actual size, as a series of 8 kbps sub-channels within each 64 kbps channel. Sub-channels 1 through 7 are typically

reserved for data while sub-channel 8, known as the Service Channel (SC), carries control information and data. During each time slot, one bit from each sub-channel is used to form an octet. 80 such octets are combined to make a frame. Frames are grouped in pairs, called sub-multiframes. 16 frames, or 8 sub-multiframes, are combined to form a multiframe. The single frame structure is shown in the following table. (ITU-T H.221, 1993, pp. 1-4)

Bit Number								
1	2	3	4	5	6	7	8 (SC)	Octets
Sub-channel# 1	Sub-channel# 2	Sub-channel# 3	Sub-channel# 4	Sub-channel# 5	Sub-channel# 6	Sub-channel# 7	FAS	1..8
							BAS	9..16
							ECS	17..24
							Sub-channel# 8	25..80

Table 2. H.221 Frame Structure (After ITU-T H.221, 1993, p. 2)

The Frame Alignment Signal (FAS) carries information about the structure of the frames and multiframes, as well as control, alarm, and error-checking information. The FAS occupies the first 8 bits (bits 1 through 8) of the Service Channel (SC). (ITU-T H.221, 1993, p. 1)

The Bit-rate Allocation Signal (BAS) occupies bits 9 through 16 of the Service Channel. The BAS describes the structure of the data within a single 64 kbps channel or across several synchronized 64 kbps channels. In other words, the BAS contains the instructions for decoding the data once it reaches the distant end. (ITU-T H.221, 1993, p. 2)

The Encryption Control Signal (ECS) occupies bits 17 through 24 of the Service Channel. This segment of the frame was allocated to allow for anticipated future growth into embedded VTC data stream encryption. (ITU-T H.221, 1993, p. 2)

The rest of the frame carries data and signals as described by the BAS. In cases where a full 64 kbps channel is not available, as with switched digital service which operates at 56 kbps, 8 kbps of the channel must be used for signalling (ITU-T H.221, 1993, p. 2). H.221 specifies a different frame structure for the 56 kbps case. (ITU-T H.221, 1993, p. 27)

Other specifications in H.221 include:

- procedures for recovery of frame alignment and timing

- description of a quality control cyclic redundancy check

- synchronization over multiple channels

- procedure for encoding the BAS

- tables defining values of the BAS

3. ITU-T Recommendation H.230 *Frame Synchronous Control and Indication Signals for Audiovisual Systems*

H.230 specifies control and indication (C&I) signals for the frame synchronous transmission of VTC data streams. There are three categories of C&I signals: call control; frame-synchronous transmission; and conference, data, and telematic control not requiring frame synchronization. Of the three categories, H.230 addresses only frame-synchronous transmission signals. (ITU-T H.230, 1993, p. 1)

C&I signals are identified by a code number and an alphabetic code name. Letters in each position of the alphabetic code name have specific meanings. The first character

indicates the type of signal: V for video, A for audio, L for maintenance (loopback), and M for multipoint. The second character is either C for control or I for indication. The third character identifies the specific function. As an example, AIM is the alphabetic code name for the *Audio Indicate Muted* signal. The corresponding code number is 0000 0010. (ITU-T H.230, 1993, pp. 1-6)

Some C&I signals are transmitted directly in the BAS of one sub-multiframe. Other codes (primarily those used in multipoint control) are transmitted in a sequence across the BAS portions of two sub-multiframes. In this instance, the BAS of the first sub-multiframe contains an escape sequence, specifically 1111 0001, and the BAS of the second sub-multiframe contains the code for the signal. H.230 contains a table with the complete list of C&I symbols, their codes, their transmit and receive requirements, and references to other ITU-T Recommendations. (ITU-T H.230, 1993, p. 1)

4. ITU-T Recommendation H.242 *System for Establishing Communication Between Audiovisual Terminals Using Digital Channels Up to 2 Mbit/s*

As with other ITU-T Recommendations examined to this point, H.242 is tightly interwoven with several other standards, H.221 and H.230 in particular. For its own part, H.242 describes the protocol between terminals capable of conducting audiovisual communication. (ITU-T H.242, 1993, p. 1)

Terminals must possess certain capabilities to claim compliance with H.242. Those capabilities are classified as audio, video, transfer rate, and data rate. All terminals need not possess the same capabilities to be interoperable under this standard, but all must have the

ability to send and receive at least a subset of the signals associated with the classifications listed above.

Other elements included in H.242 are:

- in-band signalling sequences

- mode initialization and mode switching while calls are in-progress

- error condition recovery

- call processing (establishment, termination, and transfer) over the network

- procedures for activating and de-activating data channels

- terminal procedures for operation over 56 kbps channels

- procedures for using extension codes in the BAS

- procedures for use of the ECS

5. ITU-T Recommendation H.261 *Video CODEC for Audiovisual Services at p x 64 kbit/s*

H.261 discusses coding and decoding of the video component of a video call in increments of one to thirty 64 kbps channels (p x 64 where $1 \le p \le 30$). Figure 2 shows the components of the CODEC and provides a necessary grounding before proceeding with the specifics of this standard.
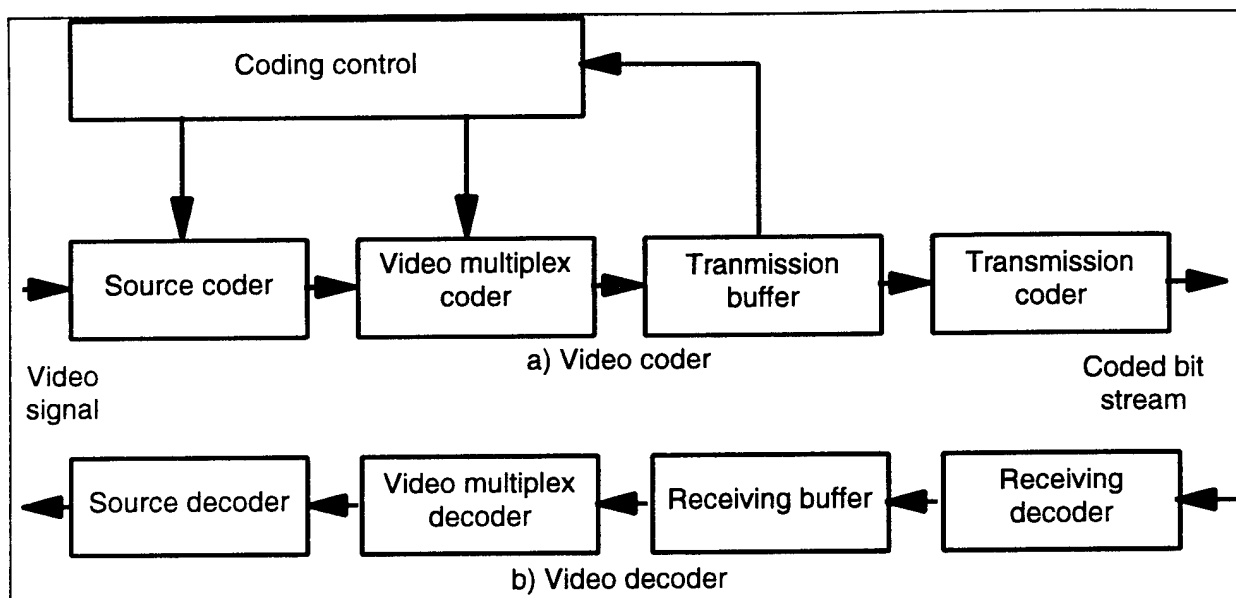
Figure 2. Block Diagram of the Video CODEC. (From ITU-T H.261, 1993, p. 2)

Compression of the video signal to accommodate transmission over decreased bandwidth is the key to making VTC affordable and is arguably the single most important aspect of video teleconferencing standardization. The topics addressed by H.261 are:

- definition of a common intermediate format (CIF) and a quarter-CIF (QCIF) for video input and output instead of a regional video standard, like NTSC or PAL

- specification of a reference for the sampling frequency to digitize the video signal

- description of the algorithm used to encode the source video

- specification of the manner in which errors are handled

- allowance for optional motion compensation and spatial filtering to augment prediction as techniques for reducing required bandwidth

- specification of the formula for the discrete cosine transform which is used to process each 8 x 8 block of picture elements (pels)

- definition of the method of quantization for digitizing the video signal

- specification of parameters for the video multiplex coder (see Figure 3)

- provision of facilities for multipoint operation

- definition of the transmission coder, which includes specifics on Bose, Chaudhuri, and Hocquengham (BCH) forward error correction (FEC)

(ITU-T H.261, 1993)

6. The BONDING Standard

The BONDING standard, specifies techniques for dividing a large capacity data stream into smaller data streams and subsequent recombination at the distant end, a technology known as inverse multiplexing or aggregation. For example, users may choose to aggregate six restricted channels (56 kbps) for a total bandwidth of 336 kbps or six unrestricted channels (64 kbps) for a total bandwidth of 384 kbps. The ability to create virtual high throughput circuits greatly increases video and audio quality while avoiding the tremendous expense normally associated with such high data rate circuits. Features of the BONDING standard include:

- definition of Mode 1 for full use of bandwidth without any reserve for diagnostics

- definition of Mode 2 for use of 98.4% of available bandwidth for use by the CODEC with the remaining 1.6% reserved for monitoring, diagnostics, and realignment.

- definition of Mode 3 for using the appropriate number of channels to accommodate the data stream from the CODEC plus an additional channel for exclusive use by the inverse multiplexer (IMUX).

- definition of Mode 0 for call setup

- specifications for channel synchronization

- definition of frame structure

(Fredette, 1994, pp. 43-45)

7. COS Profile

The Corporation for Open System International standard for video teleconferencing, the COS Profile, is the officially sanctioned document for VTC standardization within the Department of Defense (Castleman, 1994). The majority of the COS Profile applies to all video users, but Appendix B includes specifications that are unique to DoD, thereby creating an all-encompassing document satisfying the needs of commercial users, institutional users, DoD, and other government agencies. The COS Profile embodies a number of other standards from a variety of sources. Rather than enumerate the attributes specified in the COS Profile (many of which have already been listed above), this section will present a list of the standards which contribute to the COS Profile, a sample table of Profile Implementation Conformance Statements (PICS), and highlights of the special accommodations for DoD in Appendix B.

a. Standards which constitute the COS Profile

The following is a list of the standards which provide normative references for the COS Profile.

ITU-T H.221	*Frame Structure for a 64 to 1,920 kbit/s Channel in Audiovisual Teleservices, March 1993.*
ITU-T H.230	*Frame Synchronous Control and Indication Signals for Audiovisual Systems, March 1993.*
ITU-T H.233	*Confidentiality System for Audiovisual Services, March 1993.*
ITU-T H.242	*System for Establishing Communication Between Audiovisual Terminals Using Digital Channels up to 2 Mbit/s, March 1993.*
ITU-T H.261	*Video CODEC for Audiovisual Services at px64 kbit/s, March 1993.*
ITU-T H.320	*Narrowband Visual Telephone Systems and Terminal Equipment, March 1993.*
ITU-T G.711	*Pulse Code Modulation (PCM) of Voice Frequencies, November 1988.*
ITU-T G.722	*7 kHz Audio-coding within 64 kbit/s, November 1988*
ITU-T G.728	*Speech Coding at 16 kilobits per second, September 1992.*
FIPS Pub 46-1	*Data Encryption Standard.*
FIPS Pub 81	*Data Encryption Standard Modes of Operation.*
FIPS Pub 140-1	*Security Requirement for Equipment Using Data Encryption Standard.*
FIPS Pub 178	*Video Teleconferencing Services at 56 to 1920 Kb/s, December 1992.*

EIA-366-A	*Interface Between Data Terminal Equipment and Automatic Calling Equipment for Data Communications.*
NIUF Profile 940007	*NIUF Video Teleconferencing Application Profile.*
NIUF	*A Catalog of National ISDN Solutions for Selected NIUF Applications.*

(COS Profile, 1994, pp. 2-3)

b. Profile Implementation Conformance Statements (PICS)

PICS are the exact specifications that manufacturers must satisfy to be in compliance with a standard. They provide the precise clause in the applicable standard which must be fulfilled. Two tables of PICS are presented below as examples. Table 3 contains the PICS associated with ITU-T H.261. Table 4 contains the PICS for Annex B of the COS Profile (those specific to DoD). The tables are extracted from Appendix A of the COS Profile. The column labeled *Protocol Feature* describes the specific protocol in question. *Std. Clause* refers to the paragraph in the referenced standard which addresses the Protocol Feature. *Std. Status* indicates whether the feature is mandatory (M), optional (O), or prohibited (X). (COS Profile, 1994, p. 19)

H.261 PICS		
Protocol Feature	Std. Clause	Std. Status
Source format - CIF	3.1	O
Source format - QCIF	3.1	M
Prediction	3.2.1	O
Motion compensation - encoder	3.2.2	O
Motion compensation - decoder	3.2.2	M
Loop filter	3.2.3	O

Transformer	3.2.4	M
Quantization	3.2.5	M
Clipping	3.2.6	M
Forced updating	3.4	M
Data structure	4.1	M
Video multiplex arrangement	4.2	M
Multipoint considerations	4.3	O
Transmission coder	5	M
Inverse transform accuracy specification	Annex A	M
Hypothetical Reference Decoder	Annex B	M
CODEC delay measurement method	Annex C	-
Still image transmission	Annex D	O

Table 3. H.261 PICS. (After COS Profile, 1994, p. 21)

VTC Systems - Annex B PICS		
Protocol Feature	Std. Clause	Std. Status
FIPS Pub 178	B.5.1.1	M
Transmission data rates - p=1, p=2	B.5.1.2	M
Proprietary CODEC	B.5.1.3	O
Motion rendition	B.5.1.4	M
Video teleconferencing unit (VTU) network interface	B.5.1.5	O
High resolution graphics	B.5.2	O(Note 1)
Security - interoperate with KG-194	B.5.4	O
Security - resynchronization capability	B.5.4.3.2	O
ISDN BRI	B.6.1.1	O
Secure ISDN BRI	B.6.1.2	O
Note 1: Requires no change to the VTU hardware or software; the software may be implemented on PCs connected to the VTU data ports.		

Table 4. Annex B, COS Profile PICS. (After COS Profile, 1994, p. 28)

c. *VTC standards unique to DoD*

Annex B of the COS Profile addresses those aspects of video teleconferencing which are unique to the Department of Defense. The issues addressed revolve primarily around security, but also include imagery and DoD standard electrical interfaces. Figure 3 graphically illustrates the elements of a generic VTC system which are governed by Annex B. Notice the similarity to Figure 1, which presented the VTC system and the ITU-T Recommendations associated with its constituent parts. Figure 3 adds Type 3 Encryption between the CODEC and multiplexer and Type 1 Encryption between the multiplexer and network interface. (see Chapter VI for a discussion of transmission security)
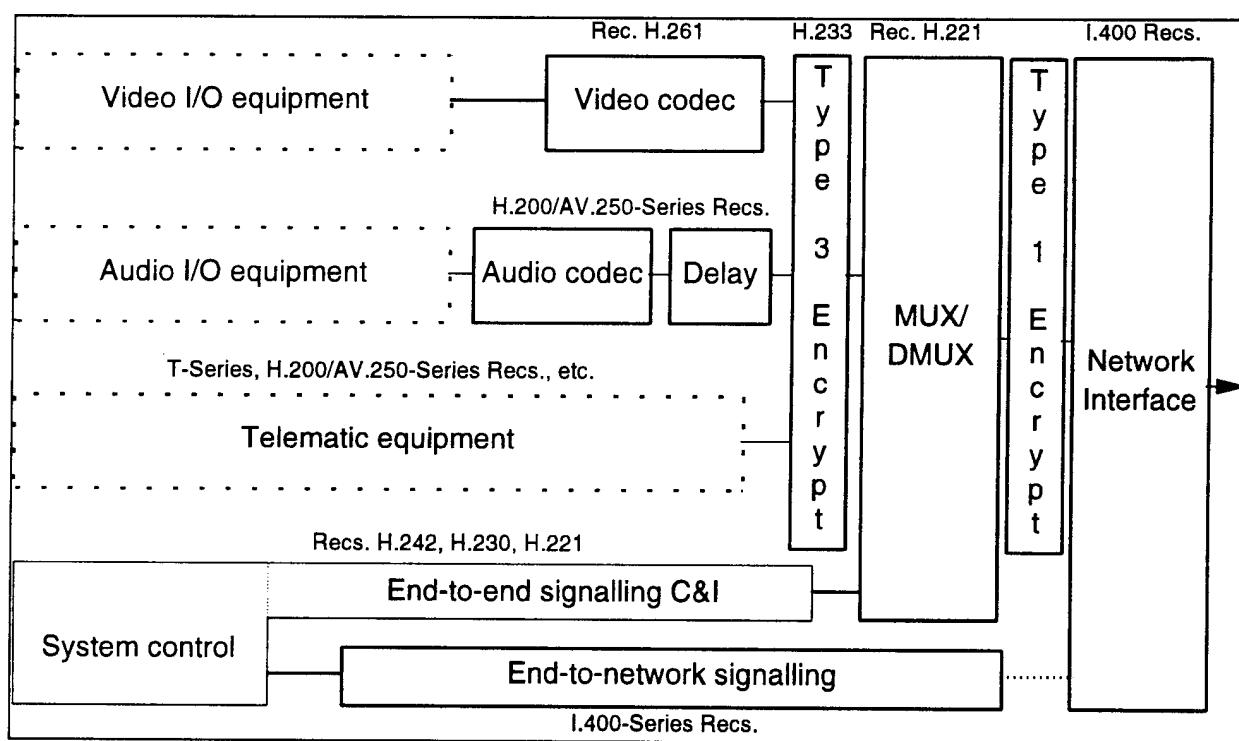
Figure 3. Scope of COS Profile Annex B (dashed boxes are not included). (From COS Profile, 1994, p. 29)

Other specifications in Annex B which depart from the main body of the COS Profile or the ITU-T H.320 series of Recommendations include:

- data transmission rate of at least p=2 (128 kbps) over a single channel or two 64 kbps channels.

- minimum level of motion rendition facilitated by an encoding rate of 6 pictures per second.

- optional, but strongly recommended, is a minimum of one synchronous EIA-449 port for connection of KG-194 cryptographic device.

- recommendation of the Joint Photographic Experts Group (JPEG) standard as specified in the National Imagery Transmission Format Standard (NITFS) for still image format.

- permission to continue using proprietary data transfer protocols until the ITU-T T.120 series of Recommendations are finalized and products which support those standards become available.

- definition of three levels of security: unencrypted, unclassified but sensitive (Type 3), and classified (Type 1).

- specification of interfaces and operating characteristics associated with Type 1 cryptographic equipment.

- descriptions of two options (one for unclassified and one for classified) for ISDN BRI interface.

(COS Profile, 1994, pp. 42-49)

D. DoD'S POSITION ON STANDARDS

An organization as large and diverse as the Department of Defense must be very concerned about the way interfaces are treated. Organizational loyalty, malaise, unwillingness to act, or delay in taking action can result in the proliferation of several systems all designed to accomplish the same task and yet unable to interoperate with one another. Video teleconferencing was well on its way to becoming still another notorious example of just this sort of situation until standards compliance was mandated. A brief look at the recent history of video teleconferencing in the Department of Defense bears this out.

The higher echelons of DoD (typically at the installation level and above) had high quality, high cost VTC studios provided through the DCTN contract. Many others who wanted a VTC capability of their own, but could not afford the services offered on the DCTN contract, purchased equipment from vendors who used proprietary algorithms, such as V-Tel and Compression Labs. Others in the tactical community explored ways to accomplish VTC in a field environment using an amalgamation of commercial equipment, tactical communications, and custom made interfaces. Still others in the research and academic communities viewed video teleconferencing as an application (Multicast Backbone, also called MBONE) which could transit traditional packet-switched computer networks, like the Internet.

DoD as a whole was moving in many different directions apparently without concern for interoperability. Top level guidance was needed to establish a common direction and a common standard, but standards do not always exist, especially in new and emerging technologies. The following chronology illustrates the speed at which VTC technology is evolving and the measures taken by DoD and others to regulate its emergence without stifling its development.

- 1990. The International Telephone and Telegraph Consultive Committee (CCITT, which would later become the International Telecommunication Union - Telecommunication Standardization Sector, or ITU-T) publishes a series of recommendations covering all salient aspects of point-to-point video teleconferencing at data rates from 56 kbps to 1920 kbps. These recommendations, known as the H.320 family, include H.320, H.221, H.230, H.242, and H.261.

- 21 December 1992. The Department of Commerce under the auspices of the National Institute of Standards and Technology (NIST), release Federal Information Processing Standards Publication (FIPS Pub) 178, which adopts the H.320 family of CCITT recommendations for use by all Federal departments and agencies.

- March 1993. CCITT H.320 family of recommendations are revised and re-published as International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) Recommendations H.320, H.221, H.230, H.242, and H.261.

- October 1993. The Defense Information Systems Agency (DISA) joins the Corporation for Open Systems International (COS) and begins work on a profile of video teleconferencing standards that will apply to industry and government. (Rittenbach, 1994)

- 26 October 1993. Deputy Assistant Secretary of Defense for Command, Control, Communications (DASD (C3)), Office of the Assistant Secretary of

Defense for Command, Control, Communications, and Intelligence (OASD (C3I)), Deborah Castleman, signs a memorandum which articulates the Department of Defense policy for VTC management. The memorandum applies to all future VTC procurements as well as all existing systems operating in the range between 56 and 1920 kbps. The policy directs that new systems comply with FIPS Pub 178 until the applicable military standard, MIL STD 188-331, is published. Existing systems will be upgraded as necessary to comply with MIL STD 188-331 within one year. (Castleman, 1993)

- 29 March 1994. MIL STD 188-331, *Interoperability and Performance Standard for Video Teleconferencing*, is released. This standard addresses point-to-point VTC and cryptographic devices. MIL STD 188-331 adopts the ITU-T H.320 family of standards for military VTC purposes. Multipoint standards are promised in the first revision, MIL STD 188-331A, due in March 1995.

- 29 June 1994. Secretary of Defense William Perry signs a memorandum entitled "Specifications and Standards - A New Way of Doing Business." Known in acquisition circles as the "Perry Memo", it dictates that the Department of Defense will reduce its reliance on military standards, form partnerships with industrial associations to draft standards that satisfy government requirements, develop non-government standards to replace military standards, and transfer current military specifications and standards to commercial, non-government standards. (Perry, 1994)

- 9 September 1994. The Corporation for Open Systems International (COS) releases VTC001, *COS Video Teleconferencing Profile*. Known simply as the COS Profile, it incorporates standards from ITU-T (the H.320 family), the American National Standards Institute (ANSI), DoD, and others.

- 31 October 1994. Ms. Castleman, DASD (C3I), issues another memorandum replacing MIL STD 188-331 with the COS Profile as the standard to which all

  future and existing DoD VTC systems (56 - 1,920 kbps) will conform. (Castleman, 1994)

E. THE VTC STANDARDS HORIZON

Standards are an absolute requirement for enterprises, such as DoD, which must be concerned with protecting investments in and prolonging the useful life of expensive equipment. Standards provide the means for ensuring interoperability between legacy, current, and future systems. Standards, however, must be allowed to grow in a deliberate and controlled manner to leverage advances in technology.

One may assume, or even expect, that existing standards will be revised as necessary to reflect changes in technology. Also, standards will be published to fill voids where no standard currently exists. Standards that are expected to be released in the near future impact on two main areas: multipoint teleconferencing and collaborative applications. Additionally, another standard for video coding, MPEG-2, is emerging and deserves attention from the VTC standards community.

1. Multipoint Teleconferencing

Multipoint teleconferencing is the term given to simultaneous connections of three or more video teleconferencing systems. DoD has long taken advantage of the multipoint capabilities provided by DCTN. At the higher levels of command, multipoint conferences are commonplace. However, as the trend toward less expensive hardware and bandwidth on demand develops, it is imperative that desired capabilities, like multipoint operation, be retained. While VTC system manufacturers do support multipoint operation, they currently do so on a proprietary basis. Multipoint control units (MCUs) exist today that are capable of bridging like systems running proprietary protocols or dissimilar systems operating in "standards" mode, but many of the attributes of multipoint operation are currently determined by manufacturers, as there are no standards which address multipoint operation yet. The COS Profile clearly intends to incorporate standards for multipoint operation when they are released.

2. Collaborative Applications

Shared desktop, shared data, audiographics teleconferencing, and collaborative applications are essentially synonyms for a new workgroup paradigm. The concept is that workgroup members at different locations can connect their computers together and execute a common application. The capability is available today with software like Lotus Notes, which allows a group of users to simultaneously view the same data (like a spreadsheet, database file, or word processing document), modify the contents, and annotate the screen in a color unique to each member. The authors of the COS Profile, as well as many in the VTC industry, view this capability as a natural adjunct to video teleconferencing. Not only would participants be able to see each other, they could collaborate on shared data.

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As of this writing, ITU-T is close to publishing its series of recommendations covering audiographics teleconferencing, which will fall under the umbrella document ITU-T T.120. T.120 will standardize applications like transfer of still images, transfer of binary files, screen annotation, and pointing. (COS Profile, p. 9)

3. MPEG-2

MPEG-2 is an example of an evolutionary standard. It puts in place a new specification for video and audio encoding that users may wish to adopt and to which manufacturers may wish to build. The three parts of MPEG-2, ISO/IEC 13818-1 (MPEG-2 Systems), ISO/IEC 13818-2 (MPEG-2 Video), and ISO/IEC 13818-3 (MPEG-2 Audio) were approved as International Standards in November 1994. MPEG-2 concentrates on digital transmission of TV quality video at data rates from 4 to 9 Mbps. While aimed primarily at high definition television (HDTV), MPEG-2 has applications in other areas, such as video teleconferencing. MPEG-2 was developed in coordination with ITU-T and is reflected in ITU-T Recommendation H.262. Both MPEG-2 and ITU-T H.262 are backwardly compatible with MPEG-1 and ITU-T H.261. (Filippini, 1995)

F. STANDARDS SUMMARY

The need for standards is undeniable and the existence of a powerful suite of commercial standards for video teleconferencing makes that need easier to satisfy. DoD's move to legislate inclusion of commercial standards for procurement of all new VTC systems and retrofit of all existing VTC systems will be the catalyst to facilitate migration to VTC

systems of the future. Subsequent adoption of new or revised standards will keep DoD's

video capability near the forefront of technological innovation.

V. MIGRATION STRATEGY

DoD needs a long term strategy for the use, development, and acquisition of video teleconferencing systems. DISA has been slow to adequately define or implement a DISN architecture for the future, thus making it difficult to develop a video teleconferencing migration strategy. DoD's release of its long awaited DISN program strategy on March 2, 1995 helps to begin defining a video teleconferencing migration strategy. The new DISN program strategy calls for the evolutionary development of a new DISA owned and operated network utilizing DoD owned switches with communication pipes acquired competitively. The network is to eventually evolve to a wideband Synchronous Optical Network (SONET) running on advanced Asynchronous Transfer Mode (ATM) switches. The DISN program strategy calls for separate voice and video contracts to replace the AT&T DCTN contract that will expire in March 1996 (Brewin, 1995).

Although this strategy currently lacks specifics, it details enough of a vision that a video teleconferencing migration strategy for the future can be developed. Any video teleconferencing migration strategy should include standards, infrastructure, and future research as part of its vision. The following is a strategy we believe will work for DoD, can be managed by DISA, keeps pace with current commercial technologies, and offers the ability to continually incorporate these technologies into an open systems architecture. This strategy encompasses continued progress in the development and use of standards, continued investment in communications infrastructure, and research into leading edge technologies that show promise for integration into future networks.

A. STANDARDS

The cultural change in how the military defines standards introduced by the Secretary of Defense in 1994 initiated government and industry alliances that increased the use of commercial specifications and standards. The adoption of industry standards by government has given vendors of video teleconferencing equipment a better understanding of what features and functionality DoD users need. This is a major step forward in solving the interoperability and cost problems of the past created by military standards and specifications, and these efforts should continue to be pursued aggressively.

1. Continue the development of standards

ITU-T Recommendation H.261 covers video CODEC transmission standards for point-to-point video teleconferencing between data rates of 56 and 1,920 kbps. The adoption of this standard has had a profound effect on moving the video teleconferencing industry away from proprietary standards. DoD and industry now need standards that cover multipoint video teleconferencing. From a service needs point of view, multipoint standards are obvious. Collaborative decision making absolutely requires many-to-many interactions and multipoint video teleconferencing is a necessary underpinning. Multipoint standards define CODEC transmission standards into and between multipoint control units (MCUs). DISA's center for standards in conjunction with the Corporation for Open Systems are currently working towards the approval of industry multipoint standards, with a target date the summer 1995. The approval of industry's multipoint video teleconferencing standards would be a major step towards global interoperability.

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Additionally, standards for video transmission below 56 kbps need to be addressed. Advances in compression techniques and technology such as audiographics teleconferencing, collaborative workstations, and personal communications systems will eventually demand standards for below 56 kbps. Today's Department of Defense is about doing more with less bandwidth, and video teleconferencing below 56 kbps in some form is inevitable.

2. Use circuit switched video teleconferencing as the DoD standard

Continue using circuit switched video teleconferencing as the DoD standard. Circuit switched video (px64 kbps) is currently the most widely used within DoD. Point-to-point standards exist for its use, and have been adopted by DoD. Multipoint standards development should also be aggressively continued with a target approval date of the summer 1995.

Transition the reservation based system of circuit switched video teleconferencing to an on-demand based system. Circuit switched video services currently available on the DCTN can be contracted as an added feature to the DSN. DCTN studio multiplexers can be upgraded to support on-demand circuit switched communications. Critical C2 nodes in the current DCTN network should continue utilizing priority 24 hour connectivity, while less critical nodes should take advantage of on-demand services. Circuit switched on-demand video teleconferencing gives DoD a flexible, "pay as you need it" network. Video data rate connections can be established based on the necessary level of quality needed, as opposed to the majority of DCTN connections today which are at the DS-1 rate, and paid for 24 hours a day, seven days a week regardless of usage.

Although circuit switched video technology may give way to packet switched video teleconferencing in the future, there are many advances that must first be achieved in order

for such a transition to occur. Circuit switched video teleconferencing meets today's requirements.

B. INFRASTRUCTURE

"An information infrastructure is a system to deliver information that is needed when it's wanted and where it's wanted - at an affordable price." This definition is paraphrased from the definition of the National Information Infrastructure, and holds equal applicability to the DoD and the Defense Information Infrastructure. The future DISN will evolve into an amalgam of information networks, appliances, and services. The role of the DoD is to ensure that these systems and services are interconnected and interoperable in order to provide maximum capability and flexibility to the warfighter.

Current video teleconferencing systems are interconnected poorly and offer little flexibility in their use. Eliminating DCTN and moving towards an open systems approach to video teleconferencing will dramatically increase video teleconferencing interoperability.

1. Eliminate DCTN

By DoD's own admission, DCTN is a relic of another era. DCTN grew out of a need during the cold war to ensure that an effective command and control system was in place to serve the continental United States. It seems only right that this network should not depict the centerpiece of DoD's DISN network for the future. The DISN strategy document released on March 2, 1995 gives clear affirmation that AT&T's DCTN contract is going to expire. (Brewin, 1995)

Although it is now known that DoD will not extend the DCTN contract thus allowing it to expire in March 1996, it is unclear what will replace it. The DISN strategy document lacks detail in describing a DCTN follow-on acquisition. It is certain that DoD has not started soon enough on a procurement to have a successor to DCTN in place by March 1996. Therefore, the existing DCTN service must extended through a sole source contract with AT&T until a successor contract for DCTN follow-on service can be put into place. However, this contract extension should include new services such as usage sensitive billing. A contract extension gives DoD the necessary time to produce a DCTN follow-on contract.

Non-critical DCTN nodes should be considered for transition to FTS-2000 or comparable on-demand services, as part of the DCTN follow-on contract. Although DoD has long resisted such a transition in the past, the savings can no longer be ignored. Conservative estimates indicate that DoD can save more than $300 million each year by transitioning DCTN services to FTS-2000. The General Services Administration (GSA) evaluated DCTN prices in the fall of 1993 and came to the same conclusion (Masud, 1994, p. 1).

2. Add switched digital services to the current DSN

DoD should add circuit switched video services to the current DSN. DCTN connections could be transitioned to the DSN as an on-demand service. An immediate payoff of such a transition is that the DSN offers immediate overseas connectivity (Europe for example), something the DCTN has always lacked. Additionally, the DSN offers existing connections down to the tactical level. These connections are logical with the video teleconferencing paradigm shift from administrative support to supporting the warfighter.

3. Continue DISN planning and development

The DISN program strategy outlines DISA's plans to pursue an evolutionary and incremental development of the new network, rather than a "big buck, big bang" strategy. It represents an evolutionary, multi-pathed approach that will take maximum advantage of existing government infrastructure, industry's capabilities, and evolving technology. DISN, according to the strategy, will evolve into a global mega-network capable of handling voice and high bandwidth data such as video teleconferencing and imagery.

The new DISN strategy is a fresh approach that addresses faults with past networks. First, through evolutionary development, DISA achieves a graceful technology evolution from currently employed DoD-owned network equipment involving no major technology leaps. Additionally, many areas of current networks can be identified for reuse. Secondly, by defining an incremental strategy, DISA has addressed past problems such as service flexibility, technology refreshment, and opportunities for adjusting contract services. This is a major step forward from past ten year contracts that were difficult and costly to adjust.

DISA expects to end up with a wideband SONET network running on advanced ATM switches. DISA has already started bundling DoD's T1 circuits into T3 lines to form a seamless backbone to support such a network (Endoso, 1994). Besides saving money, this represents a shift from managing circuits to managing bandwidth.

The DISN strategy is an excellent framework definition to build on. DISA should continue refining this strategy, with emphasis on integration. Network management and integration are the key to global interoperability. The DISN will be DISA- owned and operated, and therefore DISA will be the integrator.

4. Make smart use of gateways

Revise the DCTN Network Enhancement Program II (NEP II). NEP II established a video network management center (VNMC) in Columbus, Ohio to allow low bit rate video (LBRV) users the ability to interoperate with larger DCTN schedule D studios. NEP II is a great idea that was contractually executed poorly. The NEP II contract, administered by AT&T, does not allow FTS-2000 users to access VNMC gateway services. In addition to the access limitations, LBRV service is expensive.

FTS-2000 is the largest switched digital network within DoD and government, but users cannot access the NEP II VNMC gateway to bridge into the DCTN network. Technologically it is possible, but not contractually. FTS-2000 users must purchase a separate AT&T LBRV connectivity to the VNMC from the nearest AT&T point of presence (POP). Prices for this service are comparable to FTS-2000, but mutually exclusive to it. FTS-2000 users must decide between paying for two separate services each month or choosing one network. As of this writing, their are only twenty one subscribers to the AT&T LBRV service, so it would be unwise to exchange FTS-2000 for AT&T LBRV service.

Additionally, the charges for an LBRV secure multipoint connection to the VNMC gateway are excessive. The VNMC was established to allow low bit rate video users gateway access to larger DCTN schedule D video teleconferencing studios. One must only assume that the motivation for such connectivity beyond solving interoperability problems, was that LBRV users could not afford the cost of establishing a DCTN schedule D studio (network connectivity alone costs $8-$13K per month depending on service). However, the cost to become an LBRV subscriber to the VNMC gateway far outweighs the benefits. AT&T ACCUNET carrier charges combined with VNMC bridging fees are a factor of four greater

than comparable FTS-2000 services. There is an additional $350 per month Defense Budgeting Office of Finance surcharge to recoup the cost of building the NEP II facility. An LBRV subscriber pays $500 per month before making any video teleconferencing connection. Each DCTN schedule D studio an LBRV subscriber wishes to video teleconference with must also subscribe to the VNMC gateway services, which will cost the schedule D studio an additional $1000 per month.

Purchasing one LBRV subscription to the VNMC gateway should give users access to any DCTN studio in the network at a reasonable price, and subscribers, regardless of carrier, should be able to dial into the VNMC gateway. A recent example of this type of low cost interoperability is the AT&T video gateway service established in September 1994 for its customers who wanted to hold video teleconferences with customers at sites served by other carriers. AT&T does not charge its customers for the gateway service, only for the switched digital service. AT&T bills other carrier sites such as Sprint and MCI for their switched digital services plus bridging fees which range from $0.75 to $1.75 per minute based on bandwidth (Wallace, 1994).

Interoperability should not come at such a high cost for such a few users. The Defense Information Infrastructures goal is seamless connectivity for all users. The NEP II program falls far short of this goal at a high cost.

5. Establish a migration path to ATM

While commercial vendors are offering limited ATM services today, seamless interoperability between vendor networks does not exist. DoD cannot afford to adopt a proprietary approach that may ultimately constrain interoperability, sacrifice crucial military

features or increase cost. The DoD must move forward with standards-based solutions as the long term goal. These considerations, coupled with the current lack of knowledge with respect to the performance of a large, worldwide ATM network mandates that the DoD pursue an aggressive but cautious approach to the introduction of ATM technology. (Herberlit, 1994)   DISA's current ATM technology insertion strategy fully embraces this approach.

DISA has adopted a three track approach to provide an aggressive introduction of ATM technology into DoD while effectively managing risks. Track I, Technology Assessment, focuses on the understanding of the technology itself, examining its use in the public and private sector, and directing its development and application in the DoD through proof-of-concept exploration and advanced technology demonstrations. The intent is to focus on key elements of the technology which can support the warfighter and identify high payoff applications that can be transitioned to prototype and pilot services. Track II, Leading Edge Services, focuses on providing operational prototype and pilot services to selected users based on Track I experience and recommendations. Track III, Fully Operational Services, provides for the transition of appropriate Leading Edge Services to fully operational, fee-for-service offerings available to DoD users, with all of the system reliability and availability implied by a standard, or core service offering. Technology insertions occur on a continuing basis. Promising applications identified in Track I are migrated as quickly as possible to fully operational capabilities as they are identified.

6. Continually refine warfighter requirements

Warfighter's needs must be precisely understood. In today's dynamic command, control, communications, and intelligence (C3I) environment, requirements change with technology. We must be able to address these changes rapidly at minimum cost.

Current technology enables the speedy implementation of prototypes as a feasible and routine practice. The process remains economical even if these prototypes are discarded. C3I systems development processes have shifted to the effective presentation of information rather than the efficient processing of data. Our thinking is incremental rather than monolithic; we seek to use what is available rather than to customize anew; and we look to distribute and locally empower rather than centrally maintain and control. (AFCEA, 1993)

The evolutionary acquisition concept of "build a little, test a little, field a little" using off-the-shelf equipment and software supports the above paradigm. Evolutionary acquisition is an alternative acquisition process used to acquire C3I systems that are expected to evolve during development and throughout their operational life (Egge, 1993). This permits new technology to reach the user much faster than is currently possible.

The U.S. Army's Battle Labs concept and Louisiana Maneuvers are perfect examples of how evolutionary acquisition combined with warfighter requirements works. The Battle Labs research improvements in functional integration to meet the warfighter's needs. They are then able to provide cost benefit relationships of technology insertion to battlefield capability. Louisiana Maneuvers is able to take the Battle Labs concept one step further by examining the effect of doctrine and material changes on the warfighter in the field. These two concepts play a major role in determining warfighter requirements in the Army, and should be used as models for the entire DoD.

C. RESEARCH

Tighter budgets, rapid developments in foreign technology, and a U.S. policy of maintaining the best fighting force in the world requires the DoD to be first in technology. Long-term military modernization can only be achieved through research. Basic research projects focus on developing new methods to address fundamental limitations in current technology.

The Advanced Research Projects Agency (ARPA) and the Joint Warfare Interoperability Demonstration (JWID) are two research vehicles that assist and accelerate positive improvements that can be inserted into C4I systems, their applications, and their supporting networks. These are just two examples of ways to continue researching video teleconferencing and its potential applications to the warfighters in the future. These and other research catalysts should be used to further exploration into packet switched video and other leading edge technologies.

1. Continue researching packet based video teleconferencing systems

DoD in conjunction with industry should continue to aggressively research alternative solutions for running live video on today's local area networks (LAN). Today's LANs were build for computer data transmission and present many problems to running live video across them. Among these problems are bursty traffic, unpredictable delays, and connectionless shared bandwidths. However, new technologies under development are slowly addressing these problems.

A recent example of one such promising new technology is 3Com's development of a new switching technology called Priority Access Control Enabled (PACE). PACE is designed

to allow Ethernet networks to handle video teleconferencing and other multimedia applications more smoothly. PACE controls latency and jitter by giving higher network priority to time-sensitive applications. It does not require upgrades to the Ethernet infrastructure but does demand Ethernet switching, which gives each user a dedicated pipe. 3Com says it will add 10 Mbps and 100 Mbps PACE technology to its next generation of switching hubs this year, with prices running approximately $150 per port. Apple plans to support PACE in its own products, and the new technology is also backed by Silicon Graphics Inc., Novell Inc., and Sun Microsystems. (Beckman, 1995)

Other solutions such as out-of-band transport (ISOEthernet), H.320 at the terminal, transcoding gateways, and IP-multicast are being developed. This inrush of new products and standards apparently was behind DISA's continued delay of awarding its $200 million video teleconferencing equipment acquisition contract since June 1994. One or more of these new technologies will become the standard to bring live video to the desktop in the near future. DoD needs to be ready to lead in the definition, implementation, and refinement of these new technologies.

2. Support research into leading edge technologies

Research must be continued into leading edge technologies. Technology changes rapidly and there is no desired end-state. We can only develop an architecture, and continually find ways to insert new technologies into it, thereby making it better. Five years ago DoD and the federal government were leaders in researching new communications technologies through various projects. One of the most notable was the governments work with the National Science Foundation (NSF), which eventually turned into what we call today

the Internet. However, with the proliferation of personal computers, workstations, and the Internet, industry has taken over this position of leadership today. This may offer one explanation why the DoD finds itself in the new position of accepting industry standards for DoD use, and not vice versa.

Currently the DoD and the federal government in conjunction with industry are in the forefront of asynchronous transfer mode research, the switching technology that is likely to make the information superhighway possible. The NSF has awarded a $50 million dollar contract to triple the speed of the NSFnet backbone (Masud, 1994, p. 3). The GSA is currently using switched multi-megabit data services in both Washington and Philadelphia. These services are supplied by the Bell Atlantic Company. These super high-speed data services allow the GSA to interconnect local area networks (LAN) and to provide LAN users access to larger mainframe computers.

One of the most recent projects for high-bandwidth networking is the Advanced Technology Demonstration Network (ATDNet) project funded by the Advanced Research Projects Agency (ARPA). The ARPA network will connect six federal agencies with ATM switches in the Washington D.C. area at the 155 Mbps, Optical Carrier-3 (OC-3), SONET rate to a SONET ring operating at 2.4 Gbps (Massud, 1994, p. 3). ATDNet is identified as the core advanced technology demonstration testbed for the "Global Grid" initiative, a sequence of development and demonstration programs designed to lead toward the long-term goal of a global information network.

Additionally, AT&T Bell Laboratories in conjunction with ARPA is exploring an intelligent node framework for incorporating enhanced multimedia network services into

emerging broadband networks (specifically ATDNet). This program was initiated in October of 1994 and seeks to establish a set of generally accepted enhanced multimedia broadband network services, create a framework for their use, and demonstrate how users can extract real value from such services. Advanced opportunities in telemedicine, distance learning, and collaborative planning could eventually be the end result of this project.

VI. TRANSMISSION SECURITY

Why is transmission security important? We are in the information age, where the demand for information and the technological capability to provide it on-demand seem to increase daily. While the cold war may be over, the information war has only just begun. The vast majority of all countries continue to want knowledge about U.S. political initiatives, military capabilities, and emerging technological discoveries. These countries continue to use aggressive intelligence collection techniques in their attempt to obtain these types of information.

Transmission security policy addresses a specific means to defeat an enemy's information warfare. These policies are based upon the perceived threats to the means by which a specific mission is accomplished. Such policies document the transmission security requirements to be placed upon resources used by an organization in support of their overall mission. These security requirements, for a video teleconferencing system, record the user organization's desired protection for its information and other system resources. There are three levels of security for the protection of information transmitted between video teleconferencing units (VTU): unencrypted, unclassified but sensitive, and classified. Information that is unclassified and not sensitive requires no protection by cryptographic equipment and can be transmitted in an unencrypted mode. Information that is unclassified but sensitive and not exempted by the Warner Amendment (as defined in Title 10, United States Code, Section 2315) shall be protected by Type 3 cryptographic equipment that is certified by the National Institute of Standards and Technology (NIST). Information that is

classified and information that is unclassified but sensitive Warner Amendment information shall be protected by Type 1 cryptographic equipment certified by the National Security Agency (NSA). (COS Profile, 1994)

A. TRANSMISSION OF UNCLASSIFIED BUT SENSITIVE INFORMATION

With the end of the cold war, there has been a gradual movement towards declassification and open sources of information. Information once considered classified is more and more being treated as unclassified but sensitive. This level of information is referred to as Type 3 information, and the government standard approved for the transmission security of such information is the Data Encryption Standard (DES) algorithm.

1. Data Encryption Standard (DES)

DES was adopted by the U.S. government in 1976 for the encryption of all non-classified communications. FIPS Publication 46 details the specifications for DES and FIPS Publication 81 details DES modes of operation. DES specifies an algorithm to be implemented in electronic hardware devices and used for the cryptographic protection of data in special purpose electronic devices (such as VTC equipment). These devices shall be designed in such a way that they may be used in a computer system or network to provide cryptographic protection to binary coded data. The DES algorithm specifies both enciphering and deciphering operations which are based on a binary number called a key. The key consists of 64 binary digits ("0"s or "1"s) of which 56 bits are used directly by the algorithm and 8 bits are used for error detection (FIPS PUB 46, 1977).

DES has been criticized for its advanced age, since all useful codes are assumed to be breakable given sufficient time. But when properly implemented, DES is still the most reliable code for the transmission of sensitive information in wide use. Ironically, the secret of DES's success is that the workings of the coding technique are not secret. Everyone from amateurs to academicians free to try to outwit the algorithm, but apparently no one has done so. DES's 56 bit key ensures the difficulty of decrypting individual messages, images, or frames depending on the application. Even a computer with parallel processors could take a day to decrypt a single message, at a cost of tens of millions of dollars. (Khan, 1994) However, this time and expense will decrease over time.

2. Video teleconferencing with DES

The need for DES encryption in DoD applications is up to the user. DoD users who choose to utilize DES confidentiality shall use the 64 bit Output Feedback Mode (OFB-64) as defined in FIPS Pub 81, Data Encryption Standard Modes of Operation. All DES implementations must be validated by NIST. Software implementations (other than firmware) are not in compliance with the COS Profile for Video Teleconferencing. Read-Only Memory (ROM), microcode, Erasable Programmable Read-Only Memory (EPROM), Compact Disk Read-Only Memory (CD-ROM), and Chip firmware implementations are acceptable.

DES encryption can be purchased on all video teleconferencing systems as an optional feature for approximately $500. Point-to-point video teleconferencing using the DES option is as simple as pushing a button prior to making the connection. Users of like video teleconferencing systems as well as users of dissimilar systems utilizing H.320 standards can interoperate using DES encryption. DES capable multipoint control units (MCU) make

multipoint teleconferencing just as user friendly. Conference sites enable their DES option

and dial into an MCU to connect to other conference sites.

B. TRANSMISSION OF CLASSIFIED INFORMATION

The protection of classified information is accomplished by encrypting the signal

output of the VTU before it enters the network interface, and decrypting the signal coming

from the network before it goes to the VTU. In order to reduce the number of encryption

devices and simplify key management for video teleconferences above 56 kbps, the VTUs

must operate in a single channel mode (using one EIA-449 interface). The cryptographic

device is placed between the network interface equipment and the VTU, as shown in Figure
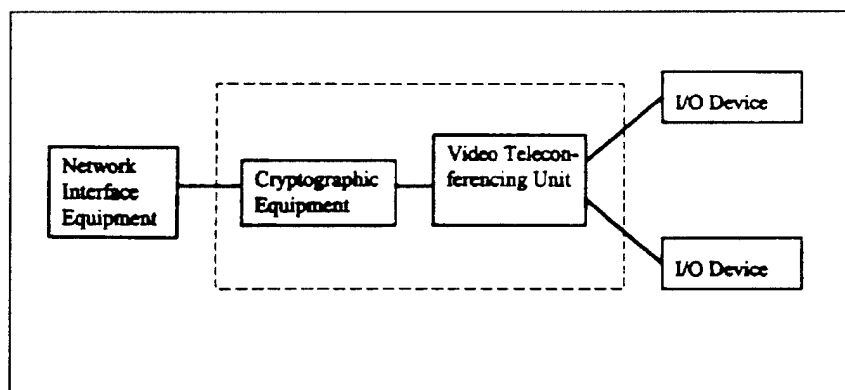
4.

Figure 4. Cryptographic Equipment Placement.

1. Cryptographic Equipment

The KG-194/194A or compatible equipment is used to protect Type 1 information.

Each transmission channel used by the VTU must be protected by the cryptographic

equipment. This requires one cryptographic unit at each VTU. If more than one transmission

channel is used, as is the case of operation at p=2 using ISDN or switched 56 circuits, then

an inverse multiplexer must be used to multiplex and demultiplex the two transmission

channels into a single cryptographic unit. (COS Profile, 1994)

The cryptographic equipment will appear to be data circuit-terminating equipment to

the VTU, and will appear to the network interface equipment as data terminal equipment. An

EIA-449 synchronous attachment port provides the capability to connect the cryptographic

equipment to the VTU. Figure 5 shows an EIA-449 (mechanical) and EIA-422-A (electrical)

connection of cryptographic equipment to a VTU and network interface equipment.
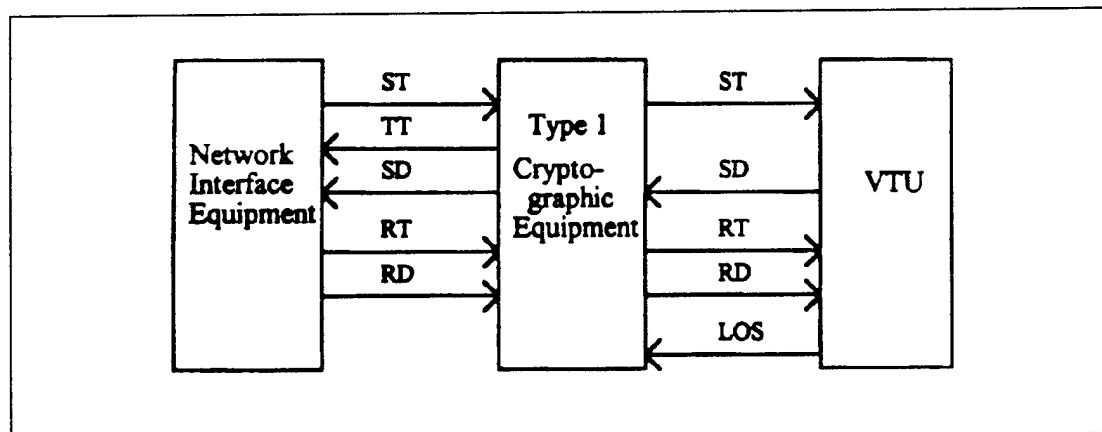
Figure 5. EIA-449/EIA-422-A VTU to Cryptographic Equipment Interface.

The interface between the VTU and the cryptographic equipment includes the

following signals in accordance with EIA-449 and EIA-422-A: Send Timing (ST), Terminal

Timing (TT), Send Data (SD), Receive Timing (RT), Receive Data (RD), and a nonstandard

loss of synchronization (LOS) signal. The cryptographic equipment does not generate a clock

signal to the network. The TT signal received from the cryptographic equipment is derived

from the ST signal provided by the network.

Classified video teleconferencing using ISDN interfaces is different. The R (Red) interface of the VTU consists of two 56/64 kbps EIA-449 ports, or one 112/128 kbps port. The R interface also includes two EIA-366-A dialing interfaces, one for each B channel. However, the EIA-366-A interface is not allowed to be physically or electronically connected during classified operation. Dialing must be performed on the network side of the cryptographic equipment. This is typically done through a terminal adaptor, which can be incorporated into the inverse multiplexer or used as a separate device. Figure 6 diagrams connections for classified video teleconferencing using multiple ISDN channels.
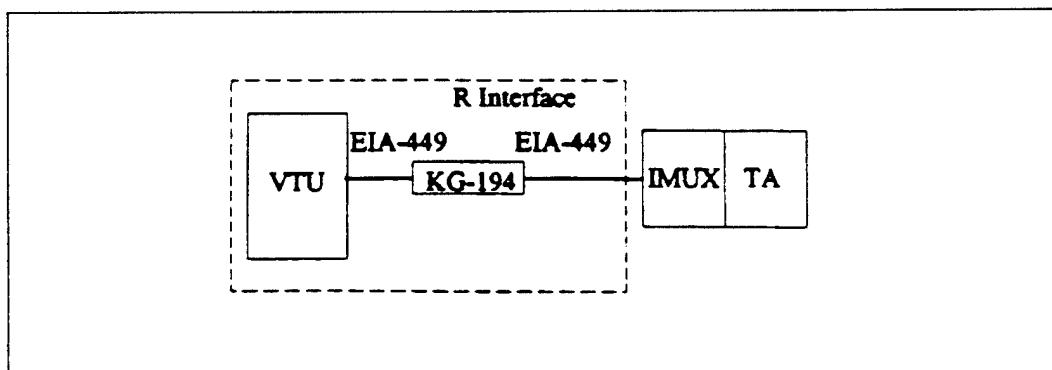
Figure 6. Classified operation over ISDN.

For the interested reader, Appendix B outlines the specific pin assignments and KG-194A strapping options for connection to a PictureTel System 4000 Model 200 video teleconferencing unit, and a Tylink ONS-400 CSU/DSU for use over an ISDN network.

2. Classified Video Teleconferencing

Point-to-point classified video teleconferencing is user friendly because standard mechanical and electrical interfaces for the connection of cryptographic equipment are defined. Operators must only ensure that the proper keying material is utilized at both ends,

and that the VTUs are capable of providing resynchronization to cryptographic equipment. However, classified multipoint video teleconferencing is more difficult. Because multipoint standards for video teleconferencing are currently not adopted, classified multipoint video teleconferences must first be decrypted before interfacing with an MCU, and reencrypted after this interface. This requires an awkward, manual interface that inhibits interoperability and frequently lowers the quality of the video teleconference. This is the primary reason why the current classified video teleconferencing architecture that exists today is reservation based.

C. MULTILEVEL SECURITY (MLS) AND VIDEO TELECONFERENCING

Multilevel security (MLS) is the enabling technology to achieve secure information system integration. Consolidation is being driven by the need for better mission performance to get information to the decision maker rapidly in a cost effective manner (NSA, 1994). Two new approaches seem poised to provide MLS solutions for packet-based video teleconferencing in the near future. They are the Multilevel Information Systems Security Initiative (MISSI) and the Network Encryption System (NES).

MISSI is an NSA initiative that seeks to provide a set of products that can be used to construct secure computer networks in support of a wide variety of missions. These evolving products when combined, provide security services for a wide variety of application environments. These products include in-line encryptors (INE), workstation products, secure server products, and security management services. MISSI is already providing security products and related services to support the Defense Message System (DMS) e-mail and file transfer applications. MISSI's long term objective is to support the MLS needs of current and emerging information systems such as the DISN, GCCS, and C4I for the Warrior.

NES is a Motorola family of products with engineering services which provides a flexible network security solution. NES was developed in cooperation with the government under NSA's Commercial COMSEC Endorsement Program (CCEP) and utilizes the Secure Data Network System (SDNS) standards. NES transmits Top Secret data over untrusted commercial networks. Charges are billed on a per-packet basis.

VII. FUTURE GROWTH

A. PURPOSE

What does the future hold for Department of Defense video users? What advancements can users expect? In order to answer the foregoing questions, this chapter will first present a scenario for overall communications technology at a point 10 to 15 years in the future, including a brief introduction to multicast backbone, or MBONE, which is a current technology that represents the most likely direction of future growth in video communication. Finally, discussions of industry's and DoD's plans for VTC will be presented.

B. THE FUTURE COMMUNICATIONS LANDSCAPE

Obviously, predicting the future of an industry which is evolving as rapidly as the communications industry is nothing more than speculation. Many factors interrelate to encourage or retard growth. These include:

- domestic and global economic trends

- social trends

- consumer preferences

- government and business application of existing and emerging technologies

- development rate of new technologies

- government regulation

(Mitre, 1993, pp. 4-1 - 4-10)

Despite the obstacles to forecasting the future, there are some trends that appear to be so well established they will no doubt significantly influence the future growth of telecommunications. These trends are:

- development of the National Information Infrastructure (NII)

- decreasing cost of bandwidth

- maturation and deployment of high throughput media and switching, especially synchronous optical networks (SONET) and asynchronous transfer mode (ATM) switching

- government downsizing

- government's increased reliance on commercial standards and acquisition of commercial-off-the-shelf (COTS) equipment

- increasing user expectations and rapid user sophistication

(Mitre, 1993, pp. 4-1 - 4-10)

C. 2010 PREDICTION

Combining those factors which are certain to influence the future with some conservative predictions about the factors whose impacts are yet unknown, the following scenario for the communications landscape of the year 2010 is offered.

1. Government

The United States federal government has continued the trend toward downsizing. Many programs which had been traditionally administered by the federal government are now within the states' jurisdictions. Government, in general, and the Department of Defense, in

particular, has recognized that the private sector now dominates the drive for new technology and that commercially available telecommunication offerings are more than adequate to satisfy government requirements. (Mitre, 1993, pp. 5-1 - 5-9)

2. Industry

With deregulation of the communication industry came mergers of companies from various niches, including telephone, cable, cellular, direct satellite broadcast, computer hardware, computer software, and entertainment. A handful of these mega-corporations control nearly all of the market share for communication and entertainment and drive practically all development of new technology. Many smaller companies are able to flourish by offering add-ons to and customization of the services offered by the big corporations. (Mitre, 1993, p. 5-3)

3. Consumers

The American population has become more stratified. Workers able to use their knowledge of the information infrastructure are among the more successful and maintain the high demand for affordable, efficient information services. The lower end of the economic scale is made up of laborers and workers who provide day-to-day services to the upper and upper-middle class. Telecommuting is common among private sector and government employees.

4. Networks

To support telecommuters and high-bandwidth entertainment applications to the home, a ubiquitous wide-area network consisting of a variety of media, including fiber optic cable,

coaxial cable, twisted pair cable, cellular radio systems, terrestrial microwave systems, and direct broadcast satellite, offers connectivity from virtually anywhere in the country. Anti-monopoly laws result in lower prices from competition among service providers. Terminal devices in the home, which combine the features of high definition television (HDTV), video telephone, computer, and interactive game machine are common among the middle and upper class. Personal digital assistants (PDAs), which combine the features of cellular phones and palmtop computers are also common. In the office, desktop applications with variable bandwidth requirements force network connections that provide bandwidth on demand. (Mitre, 1993, pp. 5-1 - 5-3)

5. Applications

The "one size fits all" network described above is designed to accommodate any application that generates data which must be moved from one place to another. Typical business applications include voice communication, computer data, imagery, and two way video. Typical home applications include all the business applications (for telecommuters) plus HDTV entertainment programming and interactive TV for virtual shopping.

6. Security

The need for security cannot be overlooked or underestimated. Security features to protect private personal communications, electronic commerce, corporate secrets residing on networked databases, and classified government information available also on networked databases will be designed into the network rather than as after-the-fact add-ons. Multilevel security (MLS) will allow authorized users to access the information they require, while

preventing unauthorized users from gaining access to information they are not allowed to have.

7. Multicast Backbone

Any discussion of the future of video communication would be incomplete without some reference to multicast backbone, or MBONE. The future described above, where video is transported over a common, Internet-like network, is happening today to some extent. Although widely regarded as experimental, MBONE has connected academia, government, and industry together in one-to-many and many-to-many video teleconferences. Simplistically, MBONE is packetized audio and video from selected transmitting sites sent over the Internet to selected receiving sites. The video quality is diminished by current low bandwidths (typically 25 - 128 kbps) and less than state-of-the-art compression algorithms, but the capability is there. (Casner, 1994)

Video over the Internet is complicated by the standard protocols employed to send data from one place to another. Transport Control Protocol (TCP) and Internet Protocol (IP) are used to package data, insert routing and control information, and assure its delivery to the proper destination. IP is designed to provide bit perfection. That is, it is more important to get all the data absolutely correct than to get it there quickly. Unfortunately, audio and video packets need to be delivered immediately. For video, timing is more critical than accuracy. Errors, within reason, are inconsequential. To get around the properties of TCP/IP that are disruptive to audio and video, MBONE requires the use of a secondary set of routers, called multicast routers or mrouters, and dedicated paths between them, called tunnels. The audio and video data is still packetized, but special header information included in the packet direct

it to the mrouter subnetwork. This network within the Internet allows delivery of VTC

services among many users over an existing network infrastructure. In this way, MBONE can

be the model for the future growth sought by both industry and government. (Macedonia,

1994)

D. INDUSTRY'S VISION FOR VTC

Narrowing the scope of this discussion to video teleconferencing, key advances in

standards, networks, CODECs, and user requirements will combine to define the VTC

landscape of the future. The following paragraphs describe the issues equipment

manufacturers and service providers will have to address to support this 2010 landscape.

1. Standards

In addition to the point-to-point standards discussed in Chapter IV and the expected

near-term standards which will govern multipoint connectivity (ITU-T H.320 multipoint) and

graphics (ITU-T T.120), standards of the future will address video telephony at data rates

below 56 kbps. Standards will also be needed to cover transport of video over the

predominantly packet-switched network. Quick promulgation of standards and equally quick

incorporation of those standards into commercially viable products will be the catalyst that

ignites sales of video units to consumers in the home and small business markets and to large

volume consumers who wish to deploy video capability throughout large organizations.

2. Networks

Today, consumers are beginning to embrace the Integrated Services Digital Network

(ISDN) as a high throughput connection to home and business capable of carrying voice,

video, imagery, and data. People are also beginning to view the common cable television (CATV) connection as another significant source of bandwidth. At the office, the familiar local area network (LAN) will offer increased bandwidth to accommodate a variety of applications, one of which will be video teleconferencing. ISDN, CATV, and LANs will offer connectivity into a single, monolithic network allowing multimode communication from anywhere to anywhere. Transport protocols will be application sensitive. Without intervention from the user, the network will know which packets require timely delivery (audio and video, for instance) and which packets require bit perfection (imagery and data, for instance). Networks will be configured in such a way to allow the substrate technology to evolve without disrupting the application layer.

3. Coder / Decoders

Innovations today in "software only" CODECs will provide a basis for miniaturized video equipment and inexpensively available computer workstation-based video systems. Without the need for bulky, costly hardware, consumers will flock to video as the natural progression in communications evolution. Video capability will be easy to add to existing computer systems and upgrades to that video capability will be as simple as downloading software from a centralized distribution center connected to the network.

4. User requirements

The critical assumption in the foregoing discussion of future video teleconferencing systems is that a community of users would have a requirement for such capabilities. Any product or service vying for the consumer's attention will have to clearly display its ability to save money or streamline operations. Video teleconferencing, however, is a technology that

has already proved its worth, as evidenced by the proliferation of VTC equipment and viability of leading VTC companies. If these companies wish to remain viable, they must anticipate (or create) new uses of their products because competitors advances will not allow customers to remain satisfied with any particular capability for very long.

The personal computer industry is a good example of how quickly users become sophisticated. Less than seven years ago, Intel's 80286 processor powered the most popular computers of the day. Today, there are no software applications being written for that processor. The growth of the computer market will likely be a representative model for the growth that the video communication market can expect. At first, the community of users will consist primarily of large corporations who can afford the technology and eclectic individuals who either see an application in the future or are enamored of the novelty (this has been the situation over the past five years or so). As the technology begins to mature and reasonable quality becomes available at low cost, VTC will attract users from medium sized companies. VTC will spawn a cottage industry of video service providers. Now, users do not have to purchase equipment or any of the trappings that come with it, like communications channels and technical personnel, they simply pay the service provider for use of the provider's equipment (this is the situation today with the prevalence of less expensive roll-about video units and VTC services offered by companies like Kinko's copy centers). Eventually, video communication will enter the mainstream. Prices for some minimum level of service will fall within reach of small businesses and average consumers. Then, video telephony will be well on the way to supplanting conventional audio-only telephony as the primary means of interpersonal telecommunications.

E. DISA'S VISION

As one might expect in an era of mandated cooperation between government and industry, the future envisioned by the Department of Defense is not so different than that envisioned by the commercial sector. Today, much work is being devoted to several projects that will mold the future of not only video communications, but communications in general within DoD. With the Defense Commercial Telecommunications Network (DCTN) contract set to expire in March 1996, plans for its successor continue to generate immense interest among those considering the long-term future of strategic communications. Likewise, plans for the follow-on to the FTS-2000 contract hold equal impact. Finally, interested parties are closely scrutinizing plans for the long awaited Defense Information Systems Network (DISN), which perhaps holds the potential of the globally interoperable network described above (at least within the Department of Defense's sphere).

In a document released in March 1995, DISA outlined its strategy for the DISN. DISA envisions the DISN as a comprehensive network capable of transporting voice, video, imagery, and data to users throughout the continental United States and to wherever U.S. forces are around the world. Although short on detail, DISA's strategy provides a general overview of the direction intended for DoD communications. (Brewin, 1995, p. 37)

DISA foresees a communications landscape where video is merely another application which transits a robust, global, packet-switched network. A complete, efficient, and economical architecture will literally extend from the foxhole to the White House over a network of government owned ATM switches and leased communications channels (of which SONET technology promises to figure heavily). A suite of applications will be overlaid onto the new, seamless network. The applications will include traditional computer applications

(such as word processing and presentation graphics), voice communications, data communications for terminal emulation, full-duplex video, imagery, and multimedia e-mail.

The DISN forms a significant part of the Government Information Infrastructure (GII), which is part of the NII, but it appears that DISA plans to isolate the DISN to a great extent from the rest of "global area network" that was predicted earlier in this chapter. There may be overriding concerns (security requirements, for instance) that make this separation desirable, but, from the authors' point of view, DISA should carefully consider all the alternatives. Any plan or acquisition that does not provide an efficient method for taking advantage of existing commercial capabilities (to the extent that they satisfy requirements) and transitioning to new technologies as they become available is insupportable on fiscal grounds. Sharing with and taking advantage of the immense technological advances in telecommunication internetworking has allowed DoD to keep pace with the civilian sector. A policy of technology based isolationism will result in a quick and certain erosion of public sector advances.

VIII. CONCLUSIONS

The intent of this thesis was to highlight the current state of video teleconferencing interoperability in the DoD and examine methods for improvement. There are at least fifteen known VTC networks within the various service components, but these networks have not fully reached their potential due to interoperability issues such as incongruous compression algorithms, dissimilar transmission speeds, a mix of public and private carriers, and incompatible communications security equipment. The principal research question was "Can VTC interoperability be achieved within DoD in a reasonable amount of time and at a reasonable cost?"

There currently is no comprehensive reference document in existence which describes the VTC assets available within the DoD, and their present state of interoperability. Many stovepipe, as well as interoperable VTC networks/systems exist throughout DoD, as do standards for their use and future procurement. This thesis also attempts to produce a consolidated document containing descriptions of DoD VTC systems, a discussion of standards for their use and procurement, a migration path for future interoperability, a discussion of transmission security, and a look at future growth issues and their effects on DoD.

Chapter II provided the reader an overview of VTC networks and systems used in DoD today. Joint systems were highlighted first, followed by Service component systems. Each system was defined within the analytical framework of system description, primary mission, network interface (data rate, compression algorithm, public or private network), and

operating costs when available. Sixteen systems were discussed. Other systems surely exist, but were unknown to the authors at the time of this writing.

Chapter III discussed interoperability problems associated with current VTC systems. Interoperability requirements for current and future systems were provided in hopes of giving the reader an overview of shortcomings that affect VTC. Issues such as data rate compatibility, non-proprietary compression algorithms, and the choice of transmission carriers were highlighted as the key attributes of an interoperable VTC system. The topic of transmission security was briefly introduced.

Chapter IV introduced the concept of standards, identified the important standards making bodies, and highlighted the standards of these organizations which impact VTC. A chronological explanation of how the DoD arrived at its present position with regards to VTC standards is presented. A brief look at the standards which will impact the future of VTC concluded the discussion of standards.

Chapter V outlined a migration strategy for the use, development, and acquisition of VTC systems, with global interoperability being the ultimate goal. This strategy encompassed continued progress in the development of multipoint and audiographics standards, investment in infrastructure such as adding switched digital services to the DSN, and research into leading edge technologies that show promise for integration into future VTC systems and networks.

Chapter VI continued with the topic of transmission security that was introduced in Chapter III. Transmission security requirements for a VTC system record the user organization's desired level of protection for its information and other system resources.

Three levels of security protection for information transmitted between VTC systems were introduced. The transmission of sensitive but unclassified information using DES, and the transmission of classified information using link/bulk encryption over VTC systems were discussed. Lastly, multilevel security (MLS), the enabling technology to achieve secure information system integration was introduced.

Chapter VII offered a glimpse into what the future may hold for DoD video users. Key advances in standards, networks, CODECs, and user requirements and how they will affect the landscape of VTC were presented. These factors were combined to offer the reader a prediction of the state of VTC in the year 2010. The chapter concluded with a discussion of both industry and DoD's visions of VTC in the future. Similarities and differences between the two visions were highlighted.

In summary, video teleconferencing is a capability in great demand, whether for distance learning, telemedicine, command and control, or any other application. users for this technology are at every level of command, in the military and out. The list includes the National Command Authority, the Joint Chiefs of Staff, Service Chiefs, the unified and specified commands, logistics agencies, medical centers, military and civilian laboratories, contractors, maneuver commanders, and many, many others. Designing a single system capable of servicing the various needs of the multitude of video users is impossible. Almost as impractical is the current situation where multiple systems exist as autonomous islands with no connectivity between themselves. The goal should be universal interoperability which would allow any user to place a video call to any other user regardless of differences in networks, carriers, or data rates.

As advances in technology continue to bring greater functionality at lower cost to virtually every field of endeavor, DoD should quickly get into position to take advantage of those advances while protecting its investment in existing VTC equipment. The key to success is standardization. Adopt commercial standards for VTC. Upgrade existing equipment to meet those standards and purchase only standards-compliant equipment in the future. Exert influence on the standards making bodies to insert new technologies rapidly and to publish updated standards reflecting those technologies quickly.

Closed networks which restrict users to communicating only with others attached to the same network must change. Modify contracts to allow easy transport out of the network and vigorously pursue the latest in networking technology, such as SONET and ATM. Consider the switched voice telephone network. Installing a private branch exchange within a building or company makes good sense. It facilitates inter-office dialing and it allows a minimum number of trunks to connect the PBX with the telephone company's exchange. But what if there was no connection with the phone company's exchange and PBX users could only call each other? A system such as that provides absolutely no utility in the workplace. So, why does the Department of Defense continue to write VTC network contracts for this same kind of limited service?

The time has come to look at the big picture and that picture shows a ubiquitous, global-area network carrying all manner of communications from anywhere to anywhere. The content (audio, video, imagery, data) and the mode (secure, nonsecure) will be irrelevant. The communications substrate will carry bits very rapidly in accordance with the transport layer protocol. The transport protocol will be an intelligent agent capable of determining the

correct method for transporting every type of data. The application layer will be independent of the transport layer allowing both to incorporate advances without regard for the other. Of course, the future described here is several years away, but the path to that future begins with open systems and a network mentality.

Can DoD achieve VTC interoperability in a reasonable time and cost? Yes, but only by first defining a vision for VTC in the DoD and a strategy to support the vision. This thesis has presented one such strategy.

APPENDIX A. CASTLEMAN MEMORANDUM

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE

WASHINGTON. DC 20301-3040
October 26, 1993

COMMAND. CONTROL.
COMMUNICATIONS
AND INTELLIGENCE

MEMORANDUM FOR DIRECTOR, INFORMATION SYSTEMS FOR COMMAND, CONTROL,
COMMUNICATIONS AND COMPUTERS (ARMY)
DIRECTOR, SPACE AND ELECTRONICS WARFARE (NAVY)
DEPUTY CHIEF OF STAFF, SYSTEMS FOR COMMAND, CONTROL,
COMMUNICATIONS AND COMPUTERS (AIR FORCE)
DIRECTOR, COMMAND, CONTROL, COMMUNICATIONS AND COMPUTER
SYSTEMS (JOINT STAFF)
DIRECTORS, J6, UNIFIED AND SPECIFIED COMBATANT COMMANDS
DIRECTOR, DEFENSE TELECOMMUNICATIONS SERVICE-WASHINGTON
DIRECTORS OF THE DEFENSE AGENCIES

SUBJECT: Department of Defense (DoD) Policy for Videoteleconferencing
(VTC) Management, Acquisition, and Standards

In order to improve interoperability and standardization of VTC
within DoD, all new procurements for VTC services and equipments will
comply with the attached policy guidance, effective immediately.

Point of contact in this office is Mr. Tom Dickinson, (703)
695-7181, DSN 225-7181.

Deborah R. Castleman
Deputy Assistant Secretary of Defense
(Command, Control and Communications)

Attachment

Department of Defense Policy
for
Videoteleconferencing (VTC) Management, Acquisition, and Standards

This policy applies to all DoD VTC activities and capabilities (including videophones, desktop, and PC-based devices which use an integral codec) which operate at data transmission rates between 56 Kbps and 1.92 Mbps. All DoD VTC services will be considered as value added offerings of the Defense Information System Network (DISN) and will be fully interoperable with the DISN. In order to ensure VTC interoperability within the DoD, the following policy is effective immediately:

- All new DoD procurements for VTC (including videophones) that operate between transmission rates of 56 Kbps and 1.92 Mbps shall conform to the requirements set forth in Federal Information Processing Standards Publication 178 (FIPS Pub 178), which references the five ITU-T (formerly CCITT) "p x 64" VTC standards, H.221, H.230, H.242, H.261, and H.320. An Interim Planning Standard 187-331 is expected to be issued in January, 1994, to provide initial standards until the late 1994 publication of MIL-STD-188-331 ("Interoperability and Performance Standard for Videoteleconferencing"). Existing DoD VTC capabilities will be upgraded as necessary to comply with MIL-STD-188-331 within one year of its approval.

- The above FIPS and MIL-STD are for point-to-point service only, and do not address multipoint or network issues. A follow-on to MIL-STD-188-331, (188-331-A), is expected in March, 1995, which will address multipoint issues. In the interim, all requirements for multipoint control units that operate between 56 Kbps and 1.92 Mbps will conform to the requirements in ITU-T (formerly CCITT) recommendations H.231 and H.243. Existing DoD VTC multipoint capabilities will be upgraded as necessary to comply with MIL-STD-188-331-A within one year of its approval.

- All intelligence activities requiring SCI-secure VTC capability will use the Joint Worldwide Intelligence Communications System (JWICS), currently being fielded by the Defense Intelligence Agency (DIA). DIA and DISA will ensure JWICS integration into the DISN, and will employ standards, applications, protocols and equipment which are in consonance with the DISN implementation.

- DISA will develop and maintain a list of VTC equipment certified as meeting applicable standards. When applicable, interoperability shall be consistent with the provisions of DoD Directive 4630.8, "Procedures for Compatibility, Interoperability and Integra-

tion of Command, Control, Communications and Intelligence (C3I) Systems." DISA's Joint Interoperability Test Center will conduct product conformance and inter-product interoperability tests and certify candidate equipment before placing it on the list. DISA's Joint Interoperability Engineering Office Center for Standards has overall responsibility for VTC standards within DoD. Interoperability will be based on MIL-STD-188-331 and 188-331-A, and on commercial product testing.

- DISA will provide contract vehicle(s) for equipment and services which will be available for use by the DoD Components to satisfy VTC requirements. No deviations from this policy are permitted unless submitted to and endorsed by DISA.

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October 31, 1994

COMMAND, CONTROL,
COMMUNICATION
AND INTELLIGENCE

MEMORANDUM FOR DIRECTORS OF THE DEFENSE AGENCIES
DIRECTOR, INFORMATION SYSTEMS FOR COMMAND,
CONTROL, COMMUNICATIONS AND COMPUTERS (ARMY)
DIRECTOR, SPACE AND ELECTRONICS WARFARE (NAVY)
DEPUTY CHIEF OF STAFF, SYSTEMS FOR COMMAND,
CONTROL, COMMUNICATIONS AND COMPUTERS
(AIR FORCE)
DIRECTOR, COMMAND, CONTROL, COMMUNICATIONS AND
COMPUTER SYSTEMS (JOINT STAFF)
DIRECTORS, J6, UNIFIED AND SPECIFIED COMBATANT
COMMANDS
DIRECTOR, DEFENSE TELECOMMUNICATIONS SERVICE-
WASHINGTON

SUBJECT: Video Teleconferencing (VTC) Standards Guidance

To improve interoperability and standardization of VTC in the Department of Defense (DoD), the OASD(C3I) issued specific policy guidance on October 26, 1993 (attached), citing the standards to implement. It cited MIL-STD-188-331 and MIL-STD-188-331A, among other standards.

Over the past year, DoD has formed an alliance with the Corporation for Open Systems International (COS), a consortium of telecommunications providers and users. Working together with COS, DoD has reached agreement on a "COS Video Teleconferencing Profile" which can be used by both industry and government in the acquisition of VTC equipment. The profile, based upon work done by the MIL-STD-188-331/331A working group, was approved on July 28, 1994. It is currently a point-to-point profile, but will be enhanced in future versions to include multipoint and other features. The standards cited in the profile are fully compatible with, and interoperable with, the federal standard for VTC, FIPS PUB 178.

The COS alliance and the resulting VTC profile supports the OSD Memorandum, dated June 29, 1994, Subject: Specification & Standards - A New Way of Doing Business (attached), which directs the Department to decrease its reliance on Military Standards and to form partnerships with industry associations for replacement of military standards, and to transfer the specifications of MIL-STDs to non-government standards.
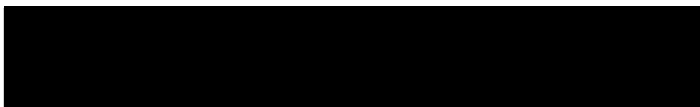
Effective immediately, all new procurements for video teleconferencing that operate between transmission data rates of 56 to 1,920 kb/s should conform to the requirements of the COS VTC Profile. This replaces the mandate to conform with MIL-STD-188-331/331A.

Paper copies of the profile (Document #VTC 001) can be obtained from the Corporation for Open Systems International, 8260 Willow Oaks Corporate Drive, Suite 700, Fairfax, VA 22031. The COS point-of-contact is Mr. David Kelley, phone 703-205-2762. Electronic access to the profile can be achieved via file transfer protocol from Host: ftp.cos.com (Username: anonymous, Password: your user name, File Directory: doc/videopro). The document is stored as two separate files, videopro.hp for use with a HP II printer and videopro.ps for use with a Post Script printer.

The Center for Standards contacts are Mr. Klaus Rittenbach and Mr. Ralph Liguori, DISA/JIEO, DSN 992-7715, Commercial 908-532-7715.

My point-of-contact for this action is Paul D. Grant who is assigned to my Communications Directorate, telephone 697-7626, E-mail Paul.Grant@OSD.Mil.

Deborah R. Castleman
Deputy Assistant Secretary of Defense
(Command, Control and Communications)

Attachments

APPENDIX B. KG-194A-TO-PICTURETEL SETTINGS

Pin Assignments PictureTel System 4000 Model 200 and the KG-194A

DB-37 Female CODEC   **KG-194A Red Side J2**

DB-37 Pin	Signal	Signal	J2 Pin
5	Send Timing A	Red Station Clock	3
23	Send Timing B	Red Station Clock (Rtn)	4
4	Send Data A	TX Plain Text	11
22	Send Data B	TX Plain Text (Rtn)	12
6	Rec Data A	Rec Plain Text	6
24	Rec Data B	Rec Plain Text (Rtn)	7
8	Rec Timing A	Red Plain Text Clock	8
26	Rec Timing B	Rec Plain Text Clock (Rtn)	9
3	Unused	Resync Level	18
21	Unused	Resync Level (Rtn)	16
19	Signal Ground	Ground	5
		Logic Ground	14
		Clear	15

Pin Assingments Between the KG-194A and the TyLink ONS 400 CSU/DSU

KG-194A Black Side J4   **DB-37 Male (CSU)**

J4 Pin	Signal	Signal	DB-37 Pin
11	TX Cipher Text	Send Data A	4
12	TX Cipher Text (Rtn)	Send Data B	22
15	TX Cipher Text Clock	Terminal Timing A	17
16	TX Cipher Text Clock (Rtn)	Terminal Timing B	35
9	Rec Cipher Text	Rec Data A	6
10	Rec Cipher Text (Rtn)	Rec Data B	24
17	Rec Cipher Text Clock	Rec Timing B	26
18	Rec Cipher Text Clock (Rtn)	Rec Timing A	8
13	Black Station Clock	Send Timing A	5
14	Black Station Clock (Rtn)	Send Timing B	23

Strapping Options for KG-194A

E-GFV Red I/O

E2 - E4   Not center tap grounded (Balanced Transmission)
E5 - E6   Contact closure One=Closed Zero=open
E11 - E12 Contact closure One=Closed Zero=open
E22 - E24 Remote actuate not connected
E27 - E28 Phase monitor enabled
E30 - E32 Normal-External control on phase select

E-GOY Xmit Board

E1   - E2   Cooperative Sync
E7   - E8   Not traffic inhibit
E10 - E11 Normal-User operation-12Mghz clock

E-GFX Receive Board

E1   -   E2   Bright display
E5   -   E6   Bright display
E9   -   E10 Bright display
E11 - E12 Continuos readout
E15 - E16 2'' time out period
E20 - E22 2'' time out period
E23 - E24 2'' time out period
E29 - E30 Primary (Mode A)
E31 - E32 Internal Clock (This is the Normal Operating Mode)

E32 - E34 External Clock

E-GFW Black I/O

E1 - E2   Single ended resync one=+.5V to 6.0V Zero = -.5V to -6.0V
E5 - E7   Single ended resync one=+.5V to 6.0V Zero = -.5V to -6.0V
E9 - E-11 External resync command not connected
E13 - E14 Single ended resync one=+.5V to 6.0V Zero = -.5V to -6.0V
E15 - E17 External change key not connected
E19 - E21 External zeroize key not connected
E23 - E25 External restart not connected
E28 - E30 Alarm high One =3.0 to 5.5V Zero=.5 to -6.0V
E31 - E32   Normal phase receive cipher clock
E33 - E34   Normal phase receive cipher clock
E36 - E38   Not center tap grounded (Balanced transmission)
E39 - E41   Not center tap grounded (Balanced transmission)
E42 - E44   Not center tap grounded (Balanced transmission)
E45 - E46   Resync achieved high One=3.0 to 5.5V Zero=-.5 to -6.0V
E49 - E50   Full operate high   One=3.0 to 5.5V Zero=-.5 to -6.0V

APPENDIX C. ORDERING STANDARDS DOCUMENTS

A. Corporation for Open Systems International (COS) Video Teleconferencing Profile

    1. Write to

        Corporation for Open Systems International

        8260 Willow Oaks Corporate Drive, Suite 700

        Fairfax, VA 22301

    2. Telephone

        (703) 205-2750

    3. Facsimile

        (703) 846-8590

B. International Telecommunications Union - Telecommunications Standardization Sector (ITU-T) Recommendations (H.320, H.221, H.230, H.242, H.261)

    1. Write to

        International Telecommunications Union

        General Secretariat - Sales Section

        Place des Nations, CH-1211 Geneva 20 (Switzerland)

    2. Telephone

        41 22 730 5285

    3. Facsimile

        41 22 730 5194

    4. Internet Uniform Resource Locator (URL)

        gopher://info.itu.ch:70

C. American National Standards Institute (ANSI) TIA-EIA-619

    1. Write to

        American National Standards Institute

        11 West 42nd Street

        New York, NY 10036

    2. Telephone

        (212) 642-4900

3. Facsimile

> (212) 302-1286

4. Internet Uniform Resource Locator (URL)

D. Federal Information Processing Standard (FIPS) Publication 46-1, 81, 140-1, and 178

1. Write to

> Defense Printing Service Detachment Office
>
> Standardization Documents Order Desk
>
> 700 Robbins Avenue
>
> Building 4, Section D
>
> Philadelphia, PA   1911-5094

or

> General Services Administration
>
> GSA Specifications Unit (WFSIS)
>
> Room 6039
>
> 7th and D Streets SW
>
> Washington, DC   20407

2. Telephone

> DPSDO: (215) 697-2667
>
> GSA: (202) 472-2205

E. Copies of ANSI, FIPS, and ITU-T standards are also included in *Open Systems Standards*, volumes 1 through 6.

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